• THE GRAMM-RUDMAN BLUFF • REDUCING THE DAMAGE FROM DAMS •

• KEEPING BUILDINGS HEALTHY •

Technology Review

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY MAY/JUNE 1986 $3.00

Mercury
Venus
*
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto

* Superpowers never resolved arms-treaty verification.

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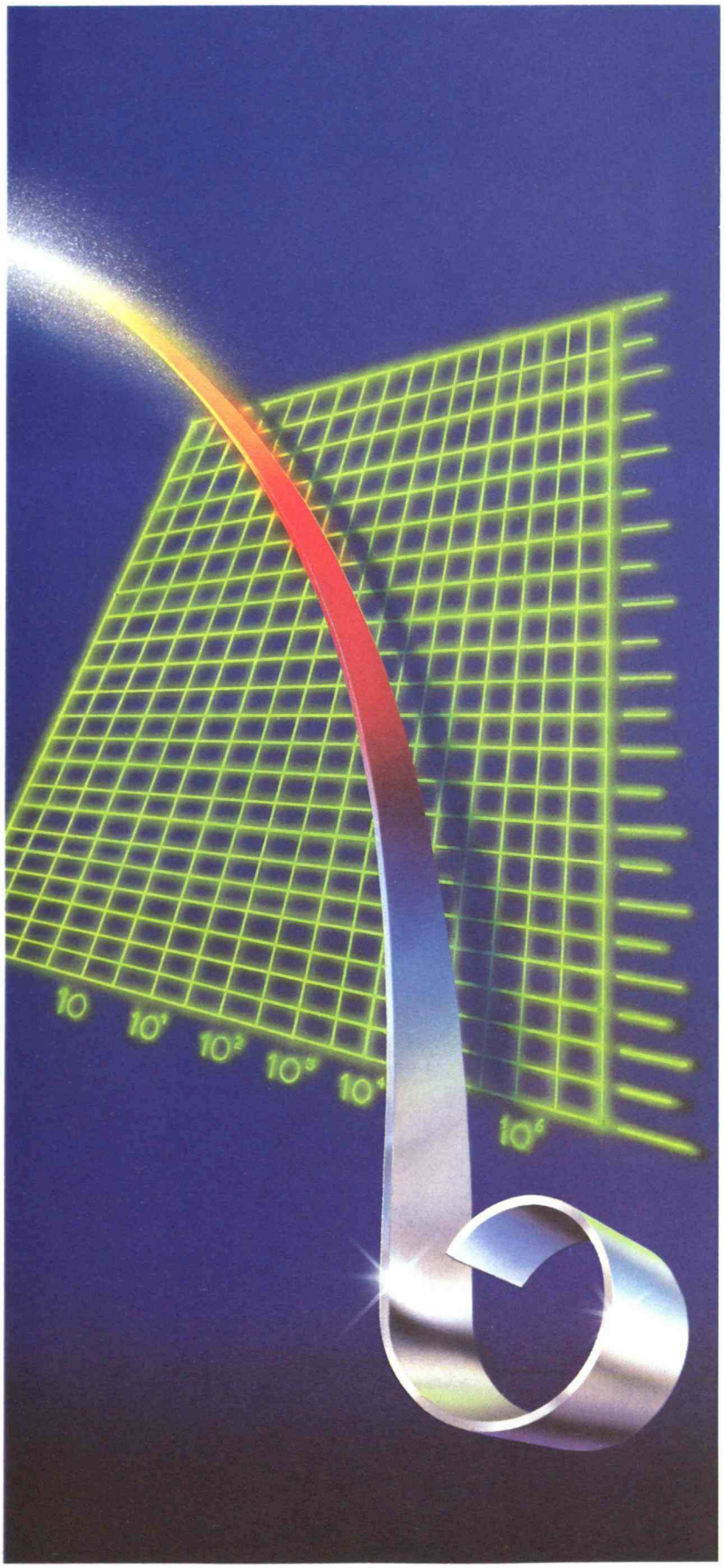
technology
review
Published by MIT



Think Fast

For a hundred years, the aluminum industry has been solidifying molten aluminum into ingot—only to remelt it elsewhere, or to heat it up or cool it down before putting an enormous amount of work into rolling it out flat.

Hmmm.

Wouldn't it be easier just to cast thin metal in the first place and skip the ingot altogether? How? Through rapid solidification.

Powder Metallurgy was the first breakthrough. And now Alcoa scientists are making major strides in two newer technologies:

Melt Spinning is a technique to form a continuous ribbon of aluminum alloy by flowing a stream of molten metal onto a rotating drum, where it cools at a million degrees per second.

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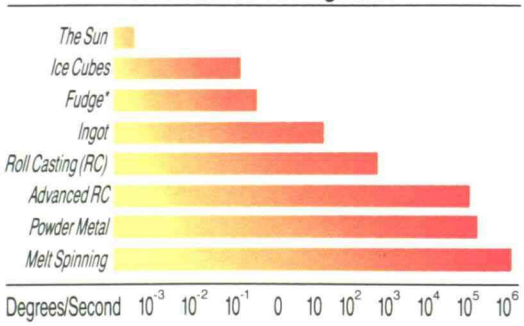
We're out to make a material difference, and our progress is accelerating.

For a closer look at what we're doing, send for our book, *The Material Difference.* Write to Dr. Peter R. Bridenbaugh, Vice President—Research & Development, Box One, Alcoa Laboratories, Alcoa Center, PA 15069.

Solidification Cooling Rates

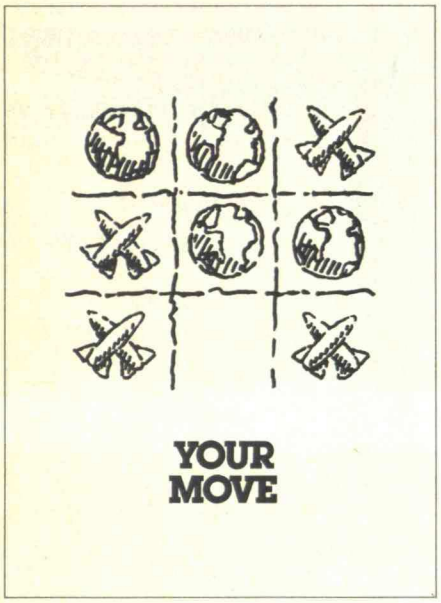


*Without walnuts

ALCOA

MAY/JUNE 1986 VOL. 89 NO. 4 EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

TechnologyReview



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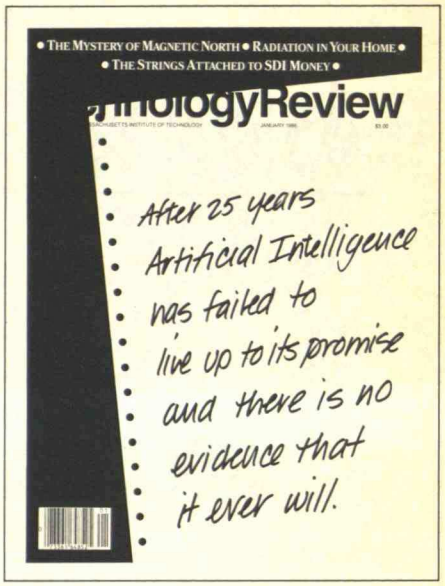
Electronic Debate

Our January cover story, "Why Computers May Never Think Like People," by Hubert Dreyfus, a philosopher, and his brother Stuart Dreyfus, a mathematician, stimulated a flood of lively comments. One of our favorites was a roguish paraphrase of our cover: "In 3,000 years philosophy has still not lived up to its promises, and there is no reason to think it ever will."

That paraphrase, which was anonymous, reached us not as a letter to the editor but electronically—in the national "open mail" channel available to M.I.T.'s Project Athena network. For a number of weeks after its publication, the Dreyfus brothers' article was one of the topics designated for comments in a category called "AIList," and users contributed several communications a day.

Another user of the system, Peter Ladkin of Berkeley, Calif., had an interesting response to the paraphrase. He noted that philosophy has spawned fields such as physics, mathematics, and even linguisitics. Artificial intelligence, he thinks, may bear similar fruits. Ladkin praised the Dreyfuses, saying they have "done AI a great service by forcing its practitioners to be more self-critical." Ken Laws, whose electronic letter originated in Palo Alto, interpreted the article as a spur for further research: the Dreyfuses "have now solidified their stronger arguments and . . . shed many of their weaker ones. I see their points as problems to be solved rather than proofs of futility." On the other hand, Paul Benjamin of Berkeley thought that the Dreyfuses' views "show a total lack of understanding of science, together with an inability to perform useful work relating to science."



We're intrigued by this mode of communication, in which members of an electronic community talk among themselves, instantaneously "publishing" comments and receiving responses. Such a network seems new and strange to those of us who air our views in print: while many people read the Dreyfus brothers' article, relatively few have access to the electronic "gossip" about it.

The electronic debate about the Dreyfus article also intrigued us by showing how broad was the article's appeal and how many people, even in the heartland of the computer revolution, found it stimulating. The electronic opinions are largely duplicated in the old-style paper letters to the editor, a first installment of which appears in the adjacent columns.—*John Mattill*

"In weighing the fate of the Earth and, with it, our own fate, we stand before a mystery, and in tampering with the Earth we tamper with a mystery. We are deep in ignorance. Our ignorance should dispose us to wonder, our wonder should make us humble, our humility should inspire us to reverence and caution, and our reverence and caution should lead us to act without delay to withdraw the threat we now pose to the Earth and to ourselves."
—From *The Fate of the Earth* by Jonathan Schell.

ABOUT THE COVER: Technology Review *is indebted to the International Typeface Corp. and its Herb Lubalin International Student Competition for this issue's cover and the art (p. 35) for Michael Krepon's report on arms-treaty verification. ITC invited students in graphic design worldwide to enter interpretations of a passage (above) from Jonathan Schell's* The Fate of the Earth. *From 900 submissions the jury selected 77 for publication in* Upper and Lower Case, *ITC's journal of typographics, and from these we chose two. The cover concept is by Karen Craig of Syracuse University, the frontispiece by John C. Youngberg of Brigham Young University.*

Arguing the Merits of Mind and Computer

"THINKING" MACHINES

In "Why Machines May Never Think Like People," (*January, page 42*), Hubert and Stuart Dreyfus misrepresent the work of Seymour Papert. They quote him as saying that he has "invented ways to take educational advantage of . . . thinking . . . in a step-by-step, literal, mechanical fashion." They go on to conclude that his approach "would leave the learner a perpetual beginner by encouraging dependence on rules and analysis."

Actually, the Papert quote, which comes from his book *Mindstorms,* is part of a passage that discusses how important it is for children to explore many different cognitive approaches. Papert points out that "by deliberately learning to imitate mechanical thinking, the learner becomes able to articulate what mechanical thinking is and what it is not. The exercise can lead to greater confidence about the ability to choose a cognitive style that suits the problem . . . Thus instead of inducing mechanical thinking, contact with computers could turn out to be the best conceivable antidote to it."

The Dreyfus brothers are similarly off base when they identify Papert as a proponent of the theory that "knowledge consists of facts and rules." Throughout *Mindstorms,* Papert argues forcefully against that theory. He sharply criticizes school math curricula for their attention to facts devoid of meaning and divorced from reality.

AARON FALBEL
MITCHEL RESNICK
Cambridge, Mass.

Aaron Falbel and Mitchel Resnick are M.I.T. graduate students working with Seymour Papert.

Hubert and Stuart Dreyfus have said what I have wanted to say for many years. Partisans of artificial intelligence do exaggerate the limited progress that has been made in that field.

However, the authors themselves could be exaggerating when they predict that if companies rely too heavily on expert systems, the "wells of true human expertise and wisdom" may dry up. A few companies could indeed have a bad experience, but in my opinion managers in other companies will react before problems become severe.

MARTY BILLETT
Barrington, R.I.

The Dreyfus brothers seem to be talking about the Machine Age that Lewis Mumford and other polemicists warned us about several decades ago: cold, deterministic, self-contained, and dangerous to the "free" human spirit. The article focuses on the sort of artificial intelligence (AI) that puts a creative mind to sleep: those commercial "expert systems" based on cumbersome, beginner-level, rule-following behavior.

The article gives scant attention to the mechanism of pattern recognition, which may already be the driving force of AI research. This mechanism employs a unified knowledge base; one example would be a collection of words related to one another in patterns. In some cases, removing a part of that base could produce a "graceful degradation"—that is, a fuzzier whole instead of a whole with one piece missing.

The Dreyfus brothers have conjured up a familiar mad-scientist scenario. If we accept their view of AI, it may be time to cast the assembly-line robot as a catastrophe-prone "battle manager" in the next disaster movie. But I still prefer Hal in *2001*: his slurred diction was clearly a graceful degradation made possible by pattern recognition.

JOHN W. BLISS
Boston, Mass.

Hubert and Stuart Dreyfus should have been careful not to assume that what is true today will be true tomorrow. Programing today's computers to emulate know-how, understanding, intuition, and other human attributes would be a very arduous task. However, saying that machines could never emulate sophisticated skills is short-sighted. The computer of the future will probably be based on a new philosophy. Who knows what might be possible with such a machine?

Granted, the mind is not like a computer. But an airplane is not like a bird, either.

A. DeLUCA
Winnipeg, Canada

Maybe computers can't think exactly like humans. But computers have proven to be *superior* to humans in performing many "semi-thinking" tasks.

One of the biggest problems artificial intelligence faces is that the education of most present-day scientists and engineers

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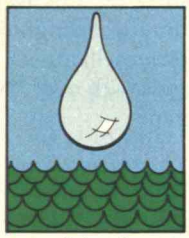
PEELING THE LASER BEAM DOWN TO ITS CORE.

AT&T Bell Laboratories scientists have generated a beam from a diode laser with a frequency spectrum 1,000,000 times narrower than that of today's most advanced commercial semiconductor lasers.

Part of a record-breaking coherent lightwave system, this laser 'peels away' a tremendous number of unwanted frequencies that can clutter up a beam—to create a lightwave so pure, its frequency variance is limited to 1 part in 40 billion. The equivalent of one drop of ink in a million-gallon, Olympic-size swimming pool.



A drop in 40,000,000,000

Purity Has Its Rewards

The new narrow-spectrum laser is the key element in a coherent lightwave communications system that increases the information-carrying capacity of an optical fiber, as well as the distance over which an unboosted laser beam can be received.

Increased capacity comes from dramatically increasing the number of individual laser beams that can be sent through a fiber's best transmission window.

Each laser in a coherent system produces an exceptionally stable, pure wavelength—allowing thousands of non-interfering wavelengths to travel side-by-side on a fiber. (Only a handful of beams can be combined using today's commercial semiconductor lasers.)

Dial 'M' For Movie

In the future, the capacity of coherent transmission could allow us to send 10 million conversations—or 10 thousand digital TV channels—simultaneously, on a single fiber.

Or, using the full capacity of a fiber, a coherent system could dump a movie like 'Gone with the Wind' into a home memory unit in one second flat. Or deliver Beethoven's '5th' in less than a 50th of a second.

Making A Little Go A Longer Way

Increasing capacity is important in an age of rapidly expanding information needs. But so is reducing costs—in this case, by nearly doubling the distance an unboosted signal can be received.

A newly developed AT&T coherent lightwave receiver contains its own narrow-spectrum laser. The beam from this laser reinforces the transmitted signal as it detects it—a technique only possible with two such pure beams.

Using this receiver, AT&T has achieved a laboratory transmission record of nearly 100 miles at a data rate of 1 billion pulses per second.

We Don't Keep The Future Waiting

Coherent lightwave transmission is just one of the ways AT&T is working toward the high-capacity, high-speed integrated networks of the future.

Meanwhile, we're bringing tomorrow closer with leading-edge lightwave systems we're building today.

AT&T this year introduced a commercial lightwave system—the FT Series G—designed to operate at up to 1.7 billion bits per second, a rate that permits the transmission of 24 thousand simultaneous calls on a single pair of fibers.

And by 1988, we'll have installed the first transatlantic and transpacific lightwave systems to Europe and the Far East—systems capable of transmitting 40 thousand simultaneous conversations on two pairs of fibers.

Clearly, whether on land or underseas, AT&T is lighting the way in lightwave. And peeling the laser beam is part of it.

AT&T

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focuses on "exact" and "analytical" systems. This is unfortunate since the most powerful computer applications may involve handling imprecise data. Medical diagnosis could be such an application.

R. C. FOX
San Rafael, Calif.

The Dreyfus brothers seem to have forgotten that intelligence is composed of a number of mental attributes, only one of which is intuition. Many human beings demonstrate minimal intuitive powers. Besides, just because a computer program cannot imitate all the attributes of human intelligence, even major ones, does not mean that AI is a failure.

Furthermore, I do not see why the authors think it is so significant that a computer cannot recognize anger. Why would any human want to "teach" such an attitude to our silicon progeny? Anger is usually counterproductive anyway.

DOUGLAS FLAHERTY
Oshkosh, Wis.

The authors respond:
We felt justified in taking the Papert quote out of context, since we believe it accurately reflects Papert's basic stand in *Mindstorms*. The last sentence of the paragraph, which Fabel and Resnick do not include in their quotation of "the rest of the passage," confirms our belief: "And for me what is most important in this is that through these experiences these children would be . . . learning to think accurately about thinking." For Papert, "thinking accurately about thinking" seems to be analogous to writing and debugging a step-by-step, literal, mechanical computer program.

Papert does acknowledge fears "that using computer models of people will lead to people losing respect for their intuitions, sense of values, powers of judgment." Accordingly, as Fabel and Resnick correctly point out, he sometimes asserts the importance of being able to choose whatever thinking and learning style is appropriate. But Papert is, to say the least, not interested in the intuitive. He treats every form of thinking and learning as analytical and procedural until proven otherwise. Throughout the book he delights in showing ways the intuitive and perceptual turn out to be procedural. See, for example, his analysis of bicycle riding and juggling. Never once does Papert suggest a case where perception might be impossible to analyze.

Our article criticized the conventional AI approach, which is based on facts and inferences. This approach has not successfully accounted for learning and pattern recognition. In our book *Mind Over Machine,* we applaud, with reservations, the sort of systems Mr. Bliss refers to.

Unlike Mr. Flaherty, we contend that intuition—the ability to draw on experience to recognize similarities among situations—is used constantly by everyone, even infants when they recognize their parents and gurgle to get attention. Logic, we believe, is much less basic, although it is useful in unfamiliar situations. Observation of real-world skills leads us to deny Flaherty's assertion that intelligence is based on logic. The failure of logic-based AI supports our denial.

STAR WARS RESEARCH

The Soviets are of course hampered by the inefficiency of their infrastructure. They must therefore be delighted to see that prestigious scientists like Vera Kistiakowsky oppose SDI research (*"Should University Researchers Accept SDI Funding?" January, page 10*). Clearly, as long as such opposition exists, we are hampered, too.

R. M. CAMPBELL
Cohasset, Mass.

THE WRONG COHEN

Page 41 of our February/March issue contains a photograph identified as one of Stanford University biochemist Stanley Cohen, who with Herbert Boyer discovered a basic method for cloning and expressing sequences of DNA in microorganisms. The photograph that appears was that of biochemist Stanley Cohen of Vanderbilt University. Stanford's Cohen is shown below. We regret the error.

Stanford's Cohen

Vanderbilt's Cohen

Fiber optics: beyond 20,000,000,000 bits/sec.

Summary:

GTE scientists have demonstrated laser modulation and detection at rates as high as 20 gigabits/second. They have developed ultra-small lasers that have light emitting areas as small as 0.2 square microns. They are working to improve the glass fiber itself, as well as to produce optical analogs of electronic switches with the long-range goal of all-optical systems, in which message streams are switched as much as 10,000 times faster than at present.

GTE commercial involvement in fiber optics communications systems dates from the first such installation in Artesia, California, in 1977.

Our scientists developed the system's technology and equipment, and have been contributing to the state of the art ever since.

Current projects deal with increasing the capacity, the versatility, the applications of the systems; longer-term, we are exploring the possibility of all-optical systems.

Faster and faster...

Until recently, optical systems processed digital streams at speeds ranging up to hundreds of megabits per second.

Fast though that may seem, today's carriers are seeking speeds in the gigabits-per-second range. This might even permit the glass to be brought directly to satellite earth stations or microwave towers, for example, for direct conversion of radio signals to light.

Recently, GTE demonstrated the ability to turn diode lasers on and off at rates as high as 20 gigabits per second—about 333% higher than the greatest previously recorded speed.

...and smaller and smaller.

Such speeds require very special lasers. And, as you can see from the electron micrograph at upper right (the head of an ant looking at one of these lasers), it is extremely small.

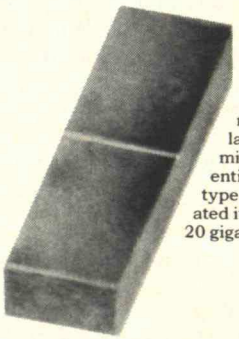
It was constructed on a wafer of InP, by epitaxial growth of a layer of InGaAsP approximately 0.1 micron thick. This was then etched to a mesa shape, and further layers of InP added.

The resulting laser cavity is approximately 0.2 square micron in area, and provides an excellent mate for single-mode glass fiber (fiber with a core of such small diameter that light travels a single path—mode—drastically lowering its dispersion within the fiber).

Switching light with light.

In another project, we are investigating the possibility of ultimately eliminating the electronics altogether by using optical switches.

We are working with materials whose indices of refraction vary with the intensity of incident light—a nonlinear response.



Head of an ant dwarfs a submicron-sized diode laser in this electron micrograph. GTE scientists developed this type laser, and have operated it at rates as high as 20 gigabits a second.

Ultimately, if it actually does become possible to switch systems optically, an improvement in speed of as much as 1,000,000% is theoretically possible.

In its brief history, fiber optics has made astonishing strides. At GTE, we are working to continue at the frontiers of this science—to make fiber optics an even more helpful technique to meet the endless needs of tomorrow's telecommunications.

The box lists some of the pertinent papers GTE people have published on various aspects of fiber optics. For any of these, you are invited to write GTE Marketing Services Center, Department FO, 70 Empire Drive, West Seneca, NY 14224. Or call 1-800-833-4000.

Pertinent Papers

High Frequency Modulation on InGaAsP Lasers: R. Olshansky and C.B. Su, 5th International Conference on Integrated Optical Fibre Communications—11th European Conference on Optical Communications, Venice, Italy, October 1-4, 1985.

140 Mb/s Transmission over 30 KM of Single-Mode Fiber Using an LED Source: L.W. Ulbricht, M.J. Teare, R. Olshansky, and R.B. Lauer, 5th International Conference on Integrated Optical Fibre Communications—11th European Conference on Optical Communications, Venice, Italy, October 1-4, 1985.

Tunable Multiplexer/Demultiplexer: Barbara Foley, John Carlsen, Paul Melman, 5th International Conference on Integrated Optical Fibre Communications—11th European Conference on Optical Communications, Venice, Italy, October 1-4, 1985.

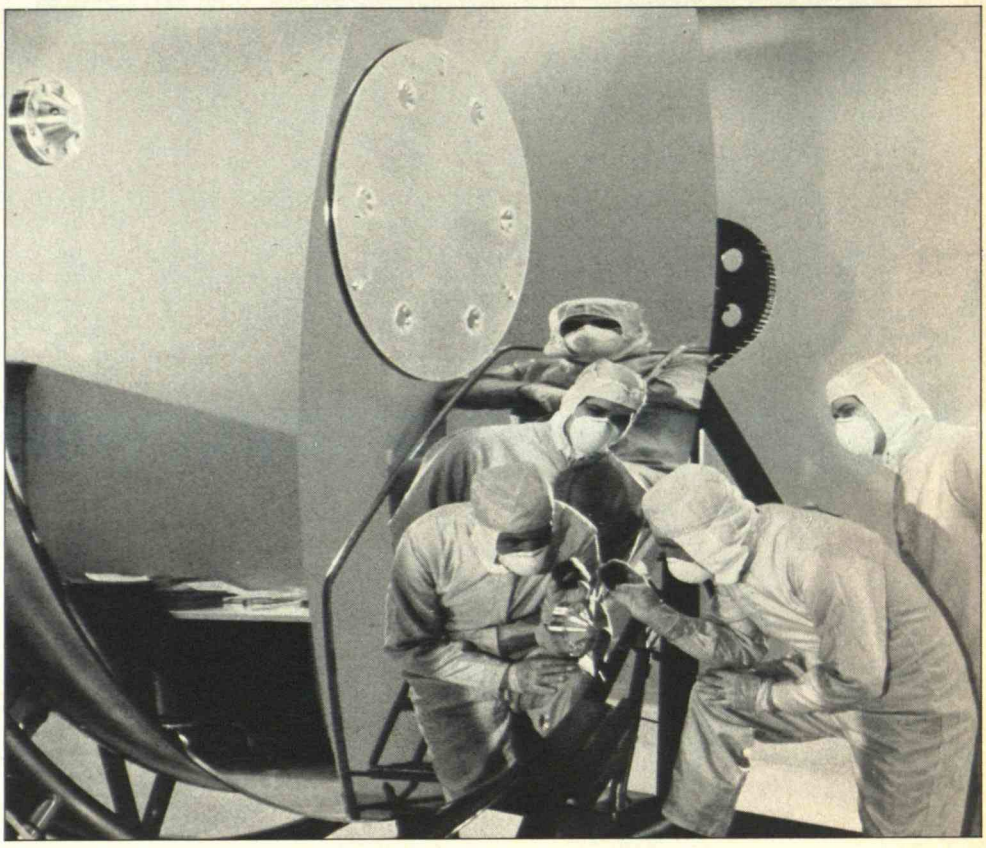
Frequency Modulation and Dynamic Lineshape Properties of Single Mode Semiconductor Lasers—Time Averaged Electric Field Autocorrelation Function Measurements: Elliot Eichen, Paul Melman, William H. Nelson, 5th International Conference on Integrated Optical Fibre Communications—11th European Conference on Optical Communications, Venice, Italy, October 1-4, 1985.

Room Temperature Optical Bistability in InGaAsP/InP Amplifiers and Implications for Passive Devices: W.F. Sharfin and M. Dagenais, Applied Physics Letter 46(9), 1 May 1985.

Time and Wavelength Resolved Nonlinear Optical Spectroscopy of a Polydiacetylene in the Solid State Using Picosecond Dye Laser Pulses: G.M. Carter, M.K. Thakur, Y.J. Chen and J.V. Hryniewicz, Applied Physics Letter 46(9), 1 May 1985.

GTE

Technicians inspect the 94.5-inch primary mirror of the Hubble Space Telescope.



Flying Telescope

The marvel of the telescope is to make the invisible visible. When Galileo focused his instrument on the moons of Jupiter, he saw what had "never been seen from the first beginning of the world until our time."

A new telescope is about to expand observable space by 350 times, providing a better understanding of how stars and galaxies evolve. Even parts of our own solar system will come into view for the first time.

Circling 320 miles overhead, the Hubble Space Telescope (HST) will avoid what has obscured the heavens until now—the atmosphere. The atmosphere blocks out ultraviolet light, scatters visible light, and makes celestial objects appear to shimmer and twinkle. Without interference from the air or from city lights, scientists will be able to focus on objects seven times farther away or fifty times fainter than they have thus far.

However, HST can point only so close to the Earth, sun, or moon, since too much solar radiation or reflected light could damage the satellite's sensitive optical system. As a result of these limits and the time needed to align the telescope and ready its instruments, observation time is limited to seven hours a day.

A joint project of the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA), HST has cost $1.2 billion, and its development has spanned a score of years. It is by far NASA's most ambitious science-development project and is intended strictly for civilian scientific research.

Named after the American astronomer Edwin P. Hubble, HST is the first of four new orbital telescopes. It will allow advances in ultraviolet and optical astronomy that scientists dreamed about in the past. NASA calls its new breed of satellites "the great observatories." Over the next 20 years, they will study the entire electromagnetic spectrum—from infrared, visible, and ultraviolet light to x-rays and gamma rays.

The heart of HST is its optical-telescope assembly, built by Perkin-Elmer Corp. The surface of the 94.5-inch mirror doesn't waver more than a millionth of an inch from a perfect curve. Perkin-Elmer engineers and technicians spent two years designing and building the equipment used to grind and polish the blank for the mirror supplied by Corning Glass Works.

The cutting was done under simulated zero-gravity conditions to prevent any distortions the weight of the 1,827-pound disk might cause. A micro-thin layer of aluminum was applied over the mirror to reflect ultraviolet light. An even thinner layer of magnesium fluoride was added to prevent oxidation from tarnishing the aluminum.

Excessive movement or temperature changes would render the satellite useless by misaligning the mirrors or scientific instruments aboard. Even temperature variations as slight as two-tenths of a degree Fahrenheit would cause the mirrors to go out of focus. So hundreds of heating pads, powered by 50,000 solar cells, keep the mirrors at 70 degrees Fahrenheit.

HST's wide-field planetary camera employs a series of detectors known as charge-coupled devices to create a picture of the light reaching it. As the workhorse of the observatory, this camera will operate almost continuously, collecting more than 30 million bits of information with each picture. It may permit scientists to discover planets orbiting nearby stars.

The expected life span of the satellite is 15 to 20 years, and each instrument on board is replaceable. Should a unit fail or become obsolete, astronauts can install another module. The instruments are also versatile. For example, HST's faint-object camera, developed by ESA, can serve as a backup should the wide-field planetary camera fail.

PHOTO: SPACE TELESCOPE SCIENCE INSTITUTE

The faint-object camera, which can photograph stars that are as faint as the twenty-eighth magnitude, will be used to study double-star systems, collapsed stars, and "globular clusters"—sphere-like collections of stars numbering into the millions.

HST's two spectrographs will study the composition of the light emitted by a star—its fingerprints. In addition, the spectrographs will provide detailed information about the most common elements in the universe—helium, hydrogen, oxygen, and carbon—and how those elements were distributed 10 billion years ago.

The simplest scientific instrument on HST, a high-speed photometer, can measure changes in light intensity that occur within millionths of a second. The photometer will help detect rapidly spinning objects, such as neutron stars. It may also give scientists insight into black holes.

With numerous delays the HST project fell three years behind schedule. The satellite was finally scheduled to be launched on the shuttle *Atlantis* October 27, but now all shuttles have been grounded in the wake of the *Challenger* disaster. Another date has not been set.

No matter when the Hubble Space Telescope begins to operate, it will inaugurate a new age of space exploration. HST will give astronomers the first clear pictures of the asteroids between Mars and Jupiter. It will take the best photos of Pluto, too, since no probe is scheduled to go there. Astronomers hope that the satellite will help answer basic questions about the age of the universe; the evolution of stars and galaxies; and, if the universe is continuing to expand, at what rate.

—Dennis A. Johnson

Shrinking genetic diversity is a threat to major food crops throughout the world. So USDA is acquiring the world's largest stockpile of plant genetic resources. The stockpile is at the National Seed Storage Laboratory in Fort Collins, Colo.

Return of the Potato Famine?

"It's not too early to be talking about catastrophe," warns Cary Fowler. "No one knows when it will strike. It could be next year; it could be 50 years." Fowler believes that shrinking genetic diversity threatens major food crops.

He and his Canadian colleague Pat Mooney, researchers at the North Carolina-based Rural Advancement Fund, are trying to counter the threat. They recently won the "alternative Nobel Prize" from Sweden's Right Livelihood Foundation for their work.

Genetic variability is important because it constitutes the first line of defense against pests and disease. When farmers rely on a variety of crops, the advance of diseases or pests is arrested when they encounter naturally resistant plants. As crops become increasingly uniform, however, a disease can sweep through them unchecked. This was demonstrated during the 1840s when the potato blight ravaged Ireland's staple crop, causing two million people to starve and millions more to emigrate.

Today's agricultural system, which promotes high yields at the expense of diversity, makes crops even more vulnerable. As plant breeders consistently select genes with the potential to boost productivity, a large proportion of the crops' original genetic base is lost—along with the capacity to resist pests and adapt to different conditions.

For example, in 1970 the Southern corn-leaf blight attacked the U.S. corn crop, reducing yields by 15 percent nationwide and more than 50 percent in some regions. At the time, three-fourths of the nation's crop consisted of only six hybrid strains.

Citrus crops are also dangerously homogeneous. In 1983 nearly two-thirds of Florida's grapefruits were of one type. Three strains made up 86 percent of the orange crop. In 1984 citrus trees fell prey to the citrus canker, a bacterial infection that led to the killing of 16 million trees. It still threatens Florida's $2.5 billion industry.

Fowler believes the long-term solution lies in biological resistance. "I make the assumption that citrus plants have seen this disease before. Somewhere, there are genes that resist it. If not, the disease would have wiped out citrus

PHOTO: USDA LABORATORY, FORT COLLINS, COLO.

crops throughout the world and we wouldn't even know the word."

International Citrus

Citrus originated in an area of China near the Vietnamese border. Botanists believe that citrus trees with natural resistance to the canker may be growing there. "They'd likely be wild trees, surely not of commercial quality," Fowler says. "First, we'd have to find them and then engage in plant breeding to get genes for resistance into commercially acceptable varieties." American scientists had planned to gather specimens in China in 1984, but the United States canceled the expedition because of trade disputes.

"Politics is often a problem," Fowler notes, "but there's also the question of whether anything's left when we get there. More and more, we're finding there's not a whole lot to be found." The trouble is that farmers from developing countries have adopted modern growing techniques and become dependent on the limited strains of seeds furnished by multinational corporations.

"When seeds are imported to the Third World, peasant farmers often stop growing their native strains," Fowler explains. "When this happens, the plants become extinct. We lose them forever." And, he suggests, "five years from now, or five hundred years from now," when a new blight hits, the only crop strain that could have staved it off may have become extinct.

Jack Harlan, a plant geneticist at the University of Illinois and perhaps the world's leading expert on genetic resources, recognized the threat decades ago. He points out the fragility of food production systems in which 80 percent of the world's people depend on wheat or rice for survival. We have become so dependent on modern, "pure line" agriculture, he says, that "each advance increases the risk and makes our food supply more vulnerable."

"About the only problem that's bigger is nuclear war," Fowler remarks. "You can't consider the possible extinction of a major food crop without assuming millions of deaths and society altered in an incredible way."

In recent years, the need to preserve genetic diversity has gained more attention, generating studies by the National Academy of Sciences, the Rockefeller Foundation, the Dag Hammerskjold Foundation, the International Board for Plant Genetic Resources, and the United Nations Food and Agricultural Organization (FAO). But substantive progress has been limited.

The U.S. Department of Agriculture (USDA) is taking significant steps by acquiring the world's largest stockpile of plant genetic resources, but a lack of funds severely hampers this effort. Fowler points out that "we allocate a little over $40,000 per year for collecting endangered varieties of food crops, a resource more valuable than OPEC's oil."

The USDA seed-storage facility in Fort Collins, Colorado—the "Fort Knox of seeds," as Fowler calls it—also suffers from chronic under-funding, managing on $450,000 annually. "The ma-

Endowed Plants

While advances in plant breeding threaten the diversity of domesticated food crops, the advance of civilization threatens thousands of wild plants. "Mankind has done more damage to plants in the past 40 years than anything else in the history of the planet," says Frank Thibodeau, co-director of the Center for Plant Conservation.

Fifteen percent of the world's flora is now threatened with extinction. Of the 22,000 plants native to the United States, about 200 have already vanished. Another 3,000 are at risk. The vast majority of these lie on private land, unprotected by government or other conservation agencies.

Conservationists maintain that many plants on the verge of extinction should be saved for aesthetic reasons alone. Thibodeau adds that there are practical concerns as well. Over 25 percent of all prescription medicines are derived, at least in part, from plant products. "The ques-

The *Iris lacustris* (top) and the *Carpenteria californica* (bottom) are two rare and beautiful American plants in need of protection.

PHOTOS: KERRY S. WALTER (TOP) AND LINDA R. McMAHAN (BOTTOM)

jor concern here is that we are rapidly running out of space," explains Eric Roos, a plant physiologist at Fort Collins.

Despite the importance of the USDA program, genetic erosion awaits a global solution. At the November 1985 meeting of the FAO, Mexico proposed a study of the possibility of establishing an international fund for conserving genetic resources. The Group of 77, a coalition of Third World Nations in the U.N., supported the proposal. According to Fowler, the United States "told the U.N. that starting up such a fund would duplicate current efforts." But, he adds, "there is no existing fund and there are no current efforts. There is no way for a poor country like Ethiopia or Thailand to get the money it needs."

Fowler thinks the situation calls for immediate international action. "If we wait until there's a large catastrophe, we've waited too long. In this field, you can't go back." —*Steve Nadis*

tion is whether you're willing to bet that there isn't another important drug out there among those 3,000 [endangered] plants," he observes.

The Center for Plant Conservation, based at Harvard University's Arnold Arboretum, has teamed up with 18 botanical gardens and research facilities across the country in a long-term program aimed at saving all of the nation's endangered plants. Rare flora are being collected, cultivated in greenhouses and gardens, and, in some cases, re-introduced to their natural habitat. As an added precaution, seeds will be stored at USDA facilities.

The project is unprecedented. The USDA's extensive collection concentrates on agricultural rather than wild plants. Monitoring endangered species throughout Europe, Kew Botanical Gardens near London offers the closest parallel. However, its program is geared more to gathering information than to collecting and cultivating the plants themselves.

Protecting plant species requires immediate action, according to Donald Falk, the center's other co-director. "If we stop to study the problem, species will disappear in the meantime." He notes that one of the usual methods for protecting rare plants—preserving their natural habitats—can be costly and sometimes inadequate. "A lot of conservation land is also used for recreation, forestry, and mining," he says.

The center's approach of private cultivation offers plants a more secure environment and also facilitates research. "We try to get plants into cultivation without damaging those in the wild," Falk says. "It's possible to propagate some plants with almost nothing—a seed, cutting, sometimes even a piece of stem or any living cell."

Ninety percent of the nation's endangered plants have never been cultivated before. In 1985, the first full year of field collections, the center cultivated 80 such species. "To our knowledge, that's the most ever done in a single year," Falk points out.

It costs about $500 per year to keep a plant alive, he estimates, and the center aims to raise a $15 million endowment. "For $5,000 you can, in essence, add a plant to the National Collection in someone's name."—*Steve Nadis*

These "mesocosms"—oceans in a tank—overlook Narragansett Bay. They help investigations of water pollution.

Experimental Oceans

Since scientists can't add oil, sewage, or radioactive compounds to the ocean, their research on the causes—and possible cures—of pollution is severely hampered. Most investigations of how pollution affects marine life rely heavily on laboratory experiments in which a particular organism is exposed to a single pollutant.

However, substances that seem quite toxic in experiments may be harmless in the ocean. For example, such substances may deteriorate rapidly or become trapped in sediments. Conversely, substances that seem relatively harmless in the lab may accumulate or concentrate in the real world. Candace Oviatt, associate director of the Marine Ecosystem Research Laboratory (MERL) at the University of Rhode Island, sums up the problem: "What does it mean if the fish turns over and dies in a beaker?"

To bridge the gap between the laboratory and the field, marine scientists have used mesocosms—large enclosures containing many species in as natural an environment as possible. These experimental oceans have aided research for over 15 years, and Denmark, Scotland, and Norway currently have active mesocosm programs. But the only such program in the United States is at MERL, overlooking Narragansett Bay.

Operating since 1976, the MERL facility consists of 14 fiberglass tanks, each with about 35 cubic feet of sediment, 459 cubic feet of water, and nearly a full complement of typical organisms from the bay. Bay water is piped in four times daily.

Of course, the MERL tanks don't completely duplicate real conditions. "We don't have whales in the tanks," she points out. Nor do the tanks hold large fish. Another difference is that the tanks lack horizontal currents. And, because the tanks are somewhat sheltered from the wind, air-water interactions are reduced. The effects of the walls are significant, too.

Still, having 14 miniature bays allows researchers to manipulate conditions in some while maintaining others as controls. Thus test results are reliable enough to use in weighing economically and environmentally important questions.

PHOTO: EPA

For example, in 1984 about a quarter of the nation's hardshell clam harvest, worth $12 million, came from Narragansett Bay. But pollution closes about a third of the bay to shellfishing. Sewage from the Providence metropolitan area is a purported cause of much of that pollution, and officials are contemplating a new sewage-treatment plant, which could cost a half billion dollars. At one point, a key issue was how much good the plant would do. Even if the bay were cleaned up, toxins and metals already in the sediment might "come out [of the sediment] and keep polluting the water for the next 100 years," said Eric Schneider, formerly director of the U.S. Environmental Protection Agency's Narragansett Laboratory and ex-science assistant to the administrator of the National Oceanic and Atmospheric Administration.

To help predict what would really happen, MERL researchers placed sediments from the heavily polluted Providence River in their tanks for two years. According to Oviatt, the experiment showed that the "problem is with the new pollutants coming in." She estimates that it would take three to ten years to establish a layer of clean sediment. This layer would prevent the pollutants in the sediments beneath from interfering with most marine life. Thus the MERL findings have removed one block to constructing the plant.

Some scientists believe MERL's emphasis on pollution is passé. "I don't think pollution is as important now as it was in the early 1970s," states George Grice, director of an earlier joint U.S.-Canada mesocosm experiment. Grice thinks future mesocosms should focus on fish-larvae survival, a crucial but little-understood aspect of fish biology.

Currently MERL researchers are beginning to look at a major problem in many coastal waters. The nutrients in municipal sewage can cause particular varieties of microscopic algae—flagellates—to multiply wildly. When the algae die and decompose, they deplete the water's oxygen, killing fish. MERL experiments are adding sodium silicate to sewage to promote the growth of a different type of algae—diatoms. Diatoms are the preferred food of zooplankton, the next higher step in the food chain. When the zooplankton eat the diatoms, algae levels go down, providing food for fish and preserving oxygen levels at very low cost.

Schneider expects that mesocosms will be crucial to future studies of toxic compounds. Such compounds can be tagged with radioactive tracers. Radioactive tracer experiments are illegal in the ocean, but thanks to the MERL tanks, researchers will be able to track many toxic substances that enter the marine environment.

—Frank Lowenstein

Stone Soup

Venice's shadings of light and dark are beloved, but the thick black crust on Venetian stone is a sign of pollution—from the nearby industrial port of Marghera and from the burning of fossil fuels.

Climate exacerbates the effects of pollution, and the air of Venice, with an average humidity of 70 percent, is damp and salty. Although Venetians traditionally used relatively compact and nonporous building materials, such as Istrian limestone, over the years soluble salts have penetrated those materials.

Further, many monuments were constructed of imported stone that already had been weathered for centuries before coming to the city, notes Sally Spector, an artist writing on Venetian building materials. Through plunder and trade, Venice collected the treasures of the East—along with their damaged building materials.

The effort to preserve Venetian architectural heritage has received international attention and money, especially since the flood of November 4, 1966. As a result, Venice has become a leading experimental center for stone restoration.

Perhaps the most exciting work is in the use of silicon and acrylic resins to repair salt damage. These synthetic resins bind the stone together by filling cavities created by salt crystals. The resins may be injected with a syringe into deep cracks or brushed over the surface so that they can be absorbed into the stone by capillary action.

Such procedures are controversial. Some synthetic resins yellow and fade, and it is unclear how they will eventually react with salts and pollutants. But Lorenzo Lazzarini, a geologist who works for the Italian Ministry of Cultural Properties, is enthusiastic about a new epoxy resin that performed well in laboratory tests designed to foresee long-term reactions. The tests subject stone to an atmosphere of sulphuric acids, ultraviolet lamps, and salt crystals. "This resin is fluid and stable and shows no color change—we're very positive," reports Lazzarini.

Restorers used the new resin on the famous granite

PHOTO: GRAZIANO ARICI

The Bovolo Staircase is one of many structures in Venice that are being restored with new materials. Here members of the Italian restoration team clean the Bovolo's belvedere.

column of San Marco, erected in the twelfth century near the ducal palace. They also used it on a seventeenth-century granite column on the nearby island of Murano that was built to honor a Venetian doge, the city's chief magistrate. Other monuments with granite columns, including Rome's Temple of Vespasian, may be restored with this resin as well.

Applying synthetic resins is often only one stage in a long process. The Minnesota chapter of the Venice Committee of the World Monuments Fund found this out when it "adopted" the Scala del Bovolo in 1979. That spiral staircase, annexed to the Palazzo Contarini in the fifteenth century, is named for a snail shell—*bovolo* in the Venetian dialect. The arched windows of the round tower enclosing this staircase reveal the Istrian limestone steps that had begun to deteriorate.

After 37 of the 70 steps had separated from the central column, architect Mario Piana and engineer Walter Gobbetto decided to rejoin them with stainless steel. As often happens, more problems appeared in the course of restoration. In July 1982, when workers removed a nineteenth-century brick buttress, they discovered major cracks in the central column and the capital at its top. While a hydraulic jack supported the staircase, broken pieces of the capital were reattached with a special mortar and stainless steel pins—an extremely delicate process.

Once the staircase was secured, a team of Venetian restorers could remove the crust of carbon, dirt, and gypsum that had formed in areas where the cleansing rain hadn't reached, such as under the steps or in the carved sections of the capitals. Areas like these are sometimes cleaned with a high-powered water spray, but this method can cause salts to migrate. So the team used a micro-sand-polisher—actually a precision sandblaster—powered by compressed air. The stone columns of the Bovolo's belvedere were treated with chemical packs containing bicarbonates of sodium and ammonia, plus a bi-sodium salt—a cleanser developed at the Central Institute of Restoration in Rome. When the incrustations softened the team removed the packs and rinsed the stone with water to wash away any remaining salts. Then they protected the stone with two or three coats of resins.

Venice has moved to the forefront of new restoration techniques and produced skilled artisans for the rest of the world. The island of San Servolo boasts the European Center for Training Craftsmen in the Conservation of the Architectural Heritage. Since 1977 the center has provided advanced training for men and women from developing countries as well as from Europe. Wolf Elbert, the architect who directs the center, emphasizes the importance of training people in how to use technological developments: "If you simply export Western technology, monuments may be in the hands of untrained craftsmen at home."

There's more than one way in which Venice belongs to the world.

—*Karen Rosenberg*

Solids Built Like Liquids

As most liquids solidify, their molecules arrange themselves into crystals—water turns to ice, molten steel to a crystalline solid. There are exceptions. In 1960 Pol E. Duwez, professor of applied physics at Caltech, created a non-crystalline—or amorphous—form of steel: cool molten steel with extremely low temperatures so that it goes into the solid state almost instantaneously. The molecules simply haven't time to arrange themselves into crystals.

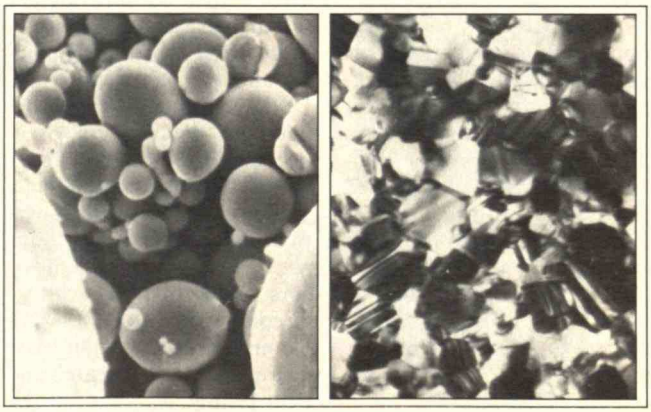
What was a curiosity a quarter century ago is now a major frontier in materials engineering. Rapid-solidification technology (RST) is yielding new metal alloys with greatly improved mechanical properties and increased resistance to corrosion and heat. Applied to silicon, RST produces amorphous semiconductors that are the key to a new generation of low-cost, efficient photovoltaics, which transform light into electricity. RST may also reduce the cost of transistors.

Stanford R. Ovshinsky, whose Energy Conversion Devices, Inc., has pioneered the manufacture of non-crystalline silicon, reported this spring that amorphous silicon photovoltaic cells can now capture 13 percent of the solar energy that falls on them. And he promised cells with an efficiency of 18 percent within three years. In a climate like California's, he said, such cells would make solar-generated electricity cheaper than that from fossil fuels.

"There is no way that major benefits will not arise from our collective efforts," writes Professor Nicholas J. Grant of M.I.T., a metallurgist with whom Duwez consulted in 1960 about his then-puzzling discovery. Grant has been working on RST ever since.

Rapid solidification is achieved by spraying extremely small droplets of molten metal onto a ribbon of refrigerated copper to form "splats." Cooling rates of up to 1 billion degrees per second have been achieved, but 1 million degrees per second is enough for most purposes. The goal is to make the cooling so quick and the droplets so small that solidification occurs simultaneously through-

These photos show the tight molecular structure of new alloys.



PHOTOS: NICHOLAS GRANT

out the splat. The thin splats of non-crystalline, amorphous material have to be heated with care, since crystals will form well below the melting point. So the splats are usually ground into a powder and then rolled or molded into ingots at modest temperatures but extremely high pressure—a technology called "powder metallurgy." Then the ingots are made into useful products—rods or sheets, for example—by rolling or extruding, again at lower tempertures than are used for conventional crystalline metals.

The microscopic spaces between crystals weaken conventional metals and invite corrosion. Since amorphous metals lack crystals, they lack the troublesome gaps. The result is a range of promising new heat- and corrosion-resistant alloys in which amorphous materials are combined. Alloys of aluminum and lithium are so heat-resistant that they could replace titanium in supersonic aircraft. New stainless steels are more than four times stronger than conventional stainless. Amorphous alloys will improve electromagnets by demagnetizing completely when the current is turned off. And heating the new high-strength copper alloys to 1,000 degrees Centigrade for an hour does not weaken them.

As with any new field, some opportunities and problems are being overlooked. For example, because heating amorphous materials is a problem, joining them presents difficulties. "Lack of an advanced joining technology," says Grant, "could prove to be a major barrier to growth." Still, he insists that RST is the basis for a "revolution in the control of metallic structures and properties."

—John Mattill

Biotech Mayhem

Regulatory confusion and questionable corporate practices early this spring marked the world's first two field tests of genetically altered products. These incidents have tainted the public image of the emerging biotechnology industry. They may sway some legislators and scientists to sanction tighter regulation in the research, testing, and licensing of genetic engineering products.

The more recent of these two cases raises questions about U.S. Department of Agriculture (USDA) approval. In January 1985 USDA allowed open-air tests of a genetically altered, live-virus vaccine for livestock. The tests, which began in April 1985, were probably the world's first of a genetically engineered product. USDA also licensed the company involved, Omaha-based Biologics Corp., to sell the vaccine.

The vaccine innoculates against pseudorabies, one of the most dangerous livestock diseases in the country. A veterinarian at the Minnesota Board of Animal Health estimated that livestock producers lose $1 million per month because of the disease. Thus, there is strong demand for an effective vaccine. Also, USDA claims that existing live-virus vaccines for pseudorabies may be more dangerous than the new vaccine.

However, in its approval process USDA never consulted outside scientific advisors or its own Agriculture Recombinant DNA Research Committee, set up eight years ago to review all research and field testing of living, genetically altered products. While a representative of USDA's inspection service, which approved the vaccine, stated that proper procedures were followed, many disagree. Orville G. Bentley, USDA's assistant secretary for science and education, says that the agency "should have asked the scientists" on its own DNA Research Committee for their opinions.

Officials in Michigan, Minnesota, and Illinois, where the tests were conducted, were never notified of the tests' unprecedented nature. Finally, USDA never acknowledged the existence of the vaccine program to the public or to congressional inspectors from the General Accounting Office (GAO), which recently conducted an eight-month audit of USDA's handling of biotechnology. After the Foundation on Economic Trends, a nonprofit watchdog of genetic engineering, used the Freedom of Information Act to uncover USDA's handling of this vaccine, the House Science and Technology Committee announced hearings, and USDA temporarily suspended the license for the vaccine.

Less than two weeks before the USDA case was reported, it came to light that Advanced Genetic Sciences (AGS) was responsible for an unauthorized release of a genetically altered organism in California. AGS tested Frostban—bacteria intended to increase the resistance of crops to frost—for almost a year before receiving an Environmental Protection Agency (EPA) permit to do so in November 1985. AGS injected 45 fruit trees with the experimental bacteria on the roof of its Oakland laboratory.

AGS claims that EPA guidelines on such experiments are vague, and that the company's injection of trees qualified as a contained experiment. The company also claims that Frostban—designed to displace the naturally occurring bacteria *Pseudomonas syringae*, which cause ice to crystalize on the leaves of most plants—will not cause adverse environmental consequences.

However, after federal and state hearings and government investigation of the company's practices, EPA suspended AGS's permit—the first it had ever granted for open-air testing of genetically

ILLUSTRATION: BOB DAHM

EPA suspended a permit to test a genetically altered bacterium. The bacterium was developed to help strawberries resist frost.

altered bacteria. The agency also levied the government's first-ever fine against a biotech company. The $20,000 fine for violating the national pesticides-control law was the largest allowed. Local opposition to AGS testing had also become intense after it was revealed that a proposed test site lay on the edge of a residential neighborhood near Castroville, Calif.

The actions by EPA, USDA, and the corporations involved illustrate the confusing and inconsistent nature of the regulation and monitoring of biotechnology. One government observer calls the situation "regulatory mayhem." Two pending bills could provide a remedy. Rep. Donald Fuqua (D-Fla.), chair of the Science and Technology Committee, introduced one in the House. His bill "makes this whole area uniform in the way that it is regulated," says Greg Simon, staff member of the committee's Subcommittee on Investigations and Oversight. A similar Senate bill was introduced by David Durenberger (R-Minn.).

Both bills call for establishing a Biotechnology Science Coordinating Committee whose members would include senior administrators from the three major agencies regulating this emerging field—USDA, EPA, and the Food and Drug Administration—as well as officials from the National Institutes of Health and the National Science Foundation. The bills differ in the way they propose to organize the permit structure. Fuqua's bill would establish three types of permits—initial use, expanded use, and commercial use—with the distinction based largely on the quantities of genetically engineered material to be produced. Durenberger's bill would grant experimental permits according to the type of microorganism in question, placing fewer restraints on the size of field tests.

The scientific community has been arguing about biotechnology's dangers since research opened up the prospect of releasing novel organisms. Many ecologists are concerned about the sensitivity of the ecosystem to new organisms. They cite Dutch elm disease and gypsy moth caterpillars as "exotic" strains that became devastating once they found a niche. But these scientists worry most about bacteria that might harm human health.

Testifying before the EPA, Cornell professor Martin Alexander said, "Alien organisms that are inadvertently or deliberately introduced in natural environments may survive, they may grow, and they may find a susceptible host or other environment, and they may do harm. I believe that the probability of all these events' occurring is small, but I feel that it is likely that the consequences of this low-probability event may be enormous."

Since molecular biologists' work sensitizes them to the difficulty of growing bacteria in alien environments, they tend to be more sanguine. Nonetheless, most think that genetically engineered products should be subjected to case-by-case reviews like those for new drugs. And some, such as Robert Sinsheimer, biologist and chancellor of the University of California at Santa Cruz, see a need for greater oversight.

Sinsheimer calls the recent incidents "a black eye for the industry." He is convinced of the need for legislation. "What we have now is a patchwork," Sinsheimer says. "People in government have tried to stretch existing laws to cover these new matters raised by biotechnology—essentially to cover what they weren't intended for. It should be clear from these unfortunate incidents that this approach isn't working."
—*Seth Shulman*

Medical Research–building a healthier future

If you've ever been treated for high blood pressure... heart disease...diabetes...or almost any health problem, medical progress based on research has already touched your life.

Because of medical research, polio no longer strikes in epidemic proportions every summer. Today about three-quarters of patients diagnosed as having Hodgkin's disease will survive five years or longer—as opposed to less than half twenty years ago. Current treatment options for people with heart disease and high blood pressure include medication that helps the body's natural regulators to control blood pressure and volume, enabling the heart to function with less strain.

Scientists are now working on new ways of treating such devastating afflictions as heart disease, cancer and Alzheimer's disease. They are testing new enzyme inhibitors that may control or reverse the late complications of diabetes. Forthcoming breakthroughs in understanding biological processes and treating disease may change the quality and perhaps the length of your life.

Medical research leading to such results takes years of patient, often frustrating experimentation by many different teams throughout the public and private sectors of our scientific community. The tasks involved are not simple.

Advances in research stem from a partnership that includes federal agencies such as the National Institutes of Health (NIH), universities and teaching hospitals across America, and private industry laboratories. Each partner often works independently to acquire knowledge and test new concepts. They must build on the knowledge developed in all laboratories, and they often coordinate efforts in their search for answers.

Whether an idea originates in a university laboratory or starts with basic product research carried on in the private sector, important findings percolate through the entire scientific community, where each new finding serves as a building block to establish a deeper understanding of what we are and how we function.

Medical research is an expensive process. It needs steady funding for equipment and personnel—even when progress is slow. Government and industry often work with university-based scientists and the medical profession not only in the acquisition of new knowledge and the development of new treatments, but also in funding these advances.

Now more than ever, we all must do our part to help keep the flow of discoveries active and ongoing. If funding for medical research is reduced, major advances in knowledge about some of the most dreaded diseases facing us today could be delayed for years to come.

What can you do?

- *Speak up*. Let your legislators know that you want funding of biomedical research by NIH and other government agencies to be kept at the highest possible levels.
- *Contribute* to voluntary health organizations supporting disease research.

Research-based pharmaceutical companies such as Pfizer are also increasing their financial investment in research. For instance, in 1984 alone, pharmaceutical companies in the United States spent over 4 *billion* dollars on research and product development.

At the same time, we at Pfizer realize the importance of committing more than money to research. As a partner in healthcare, we are continually working to discover new ideas, test new concepts, and turn new understanding to practical and beneficial uses. Now we are working harder than ever to make sure that this nation's medical research effort receives the attention—and funding—it deserves.

For more information on the future of medical research in America, write to Health Research U.S.A., P.O. Box 3852 FR, Grand Central Station, New York, NY 10163.

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ROBERT C. COWEN

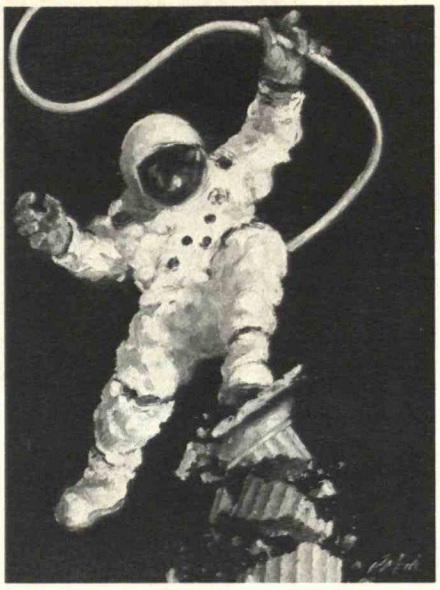
Deep-Rooted Malaise at NASA

For many veteran observers of the U.S. space program, myself included, the story that has unfolded in the *Challenger* investigation is a shocking disillusionment. The NASA that launched *Challenger* against the advice of leading contractors is no longer the agency we once knew. Although the presidential panel is still gathering testimony, its investigation has already substantiated chairman William P. Rogers' charge that NASA's launch-decision process was "clearly flawed." As panel member Joseph Sutter, executive vice-president of the Boeing Commercial Airplane Co., said, "There is a serious communication and management problem here."

The Rogers panel has avoided personal accusations, which I think is wise. Without specific evidence of negligence, it would be unfair to blame dedicated individuals for what seems to be an institutional problem that has been developing for more than a decade.

In 1972, after the last of the Apollo moon landings, the Nixon administration opted to develop the shuttle as the centerpiece of a scaled-down, more practically oriented space program. The presidentially appointed interagency Space Task Group did consider other possibilities, such as constructing space stations and sending a mission to Mars. But neither the administration nor Congress was prepared to fund another expensive space adventure. So NASA was given the task of developing the shuttle within an annual budget of $3 billion—half the funding for the Apollo program at its peak.

Aware of the political realities of the 1970s, NASA sold the shuttle program to Congress and the public in terms of its practical, commercial payoffs. NASA officials touted the advantages of using the shuttle to launch and maintain satellites for communication, weather, and earth-resource surveys. They foretold future benefits from space-manufactured drugs and materials. NASA also lobbied hard to have the Defense Department use the shuttle for launching and repairing military satellites, and to have the National Oceanic and Space Administration use it for weather satellites.



The NASA that launched Challenger is not the agency we once knew.

More recently, because of concern about the federal deficit, NASA has been under increasing pressure to further trim its programs. In response to this pressure, NASA has continued to overplay the practical payoffs of its programs and underplay its role in pure space exploration.

The Media's Failure

During the past decade, the program cutbacks and the attendant loss of morale have driven key personnel out of the agency. While some of the more dynamic and creative engineers and managers have left, others have become ossified in their jobs, according to a retired NASA behavior analyst who recently wrote to me. He said that such personnel changes have tended to "promote rigidity, a firmly entrenched 'palace guard,' and crusted or rusted communication filters."

In spite of NASA's problems, many of us had continued to believe that launch safety, at least, was still well controlled. Reporters covering NASA often heard their sources complain that the agency's overall capacity and competence were suffering. Yet we usually did not report these complaints. In fact, we overlooked warning signs that should have sent us digging into the question of launch safety. In covering NASA, the press failed in its watchdog job.

It is now clear that the unrealistic desire to make the shuttle pay off affected launch decisions. As an unnamed flight-crew operations official told the *Houston Post*, "The program people weren't listening [to safety complaints]. They were too worried about the schedule and money associated with it to pay attention."

Newspaper commentators have suggested that pressure to launch the *Challenger* on time came from NASA's much-publicized teacher-in-space program. I seriously doubt that. Since many insiders at NASA considered the whole amateur-in-space (teacher, congressperson, journalist) program premature to begin with, I don't believe NASA officials would have yielded to pressure for a public-relations coup.

Regardless of where the pressure came from, we cannot blame NASA alone for the *Challenger* disaster. Successive Congresses and administrations are also at fault, because they have failed to recognize that manned space flight remains a dangerous, pioneering endeavor. The lack of a national consensus on long-term space goals also contributes to NASA's troubles.

Political Will Is Lacking

Nearly three decades into the space age, the United States still doesn't know what it wants to do in space. The Apollo moon-exploration program was largely an effort to "beat the Russians," and it developed a rocket and spacecraft for which there was no further use. Similarly, the shuttle is a tool without a purpose significant enough to justify the expense of developing and operating it. Enthusiasts will say that the shuttle and the manned space station will open the space frontier for practical use. But most satellites would be better launched on unmanned rockets, which are cheaper and safer than manned space vehicles. In essence, the United

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ILLUSTRATION: PAUL MOCK

LESTER C. THUROW

Calling the Gramm-Rudman Bluff

SUPPOSE that I were to publicly announce that if I do not go on a diet and lose 15 pounds by the first of October, I will put my hand in the garbage disposal and grind off my fingers. What would you think about such a promise? Somebody has finally found a way to put himself on an effective diet. Or somebody is crazy; he simply won't do it.

When thinking about Gramm-Rudman, we should be asking similar questions. Gramm-Rudman essentially promises that if the president and Congress do not do something sensible to bring deficits down—raise taxes or cut spending—then the country is going to collectively grind off its fingers.

Let's examine what I mean. The fiscal 1986 budget—October 1985 to October 1986—is expected to have a $206 billion deficit. To eliminate a deficit of that magnitude, the Gramm-Rudman bill mandates across-the-board budget cuts over a five-year period, with half the money sliced from the defense side of the budget and half from the civilian side.

However, there are restrictions as to what can be cut. On the civilian side, interest on the national debt is exempted for the perfectly good reason that unilaterally defaulting on such payments would be the equivalent of declaring bankruptcy. Social Security, veterans' benefits, and a few other programs are exempt on the perhaps less valid grounds that cutting them would mean committing political suicide.

When those exemptions are made, we are left with $279 billion in civilian spending available to be cut. Pruning $103 billion, or half the deficit, from this amount would require cutting every remaining item by 37 percent. The Gramm-Rudman law mandates that each program (except those exempted) be cut equally. In his fiscal-1987 budget, President Reagan maintains that all the cuts necessary to comply with Rudman should come from the civilian side. If that happens, each and every civilian program, except those exempted, would have to be cut twice as much, or 74 percent.

What would happen then? Let's start with the federal prison system, which spends about $662 million dollars a year. A cut of either 37 or 74 percent means that the federal prisons must be closed. This poses a simple question. Whose neighborhood would all those murderers, rapists, and spies be let out in? If either 37 or 74 percent of the aircraft controllers are dismissed, the number of airplane crashes will probably increase. Who is going to be in those airplanes? With an FBI that is 37 or 74 percent smaller, Russian spies are going to be very productive. Drug smugglers must dream about a 37 or 74 percent reduction in drug-enforcement activities.

Government R&D spending would, of course, have to be cut by the same amount. And that would hurt our ability to compete in international trade, particularly in high-technology items.

Even Reagan could not find the cuts that would be necessary to meet Gramm-Rudman's requirements.

Under Gramm-Rudman as it now stands, the defense budget must be cut by $103 billion or 39 percent. Let's suppose Congress does manage to overrule a popular second-term president and achieve those mandated cuts in defense. Under the law, the cuts cannot come from existing hardware contracts and pensions. This means that all the cuts must come from operations and maintenance. Effectively, this means tanks and planes without gasoline. Normally that is called 'unilateral disarmament.'

What Gramm-Rudman promises to do if the president and Congress do not balance the budget is clearly as stupid as my promise to grind off my fingers if I do not lose weight.

A Giant Game of Chicken

One must inquire into the purpose of stupid threats. Is there any likelihood that they will actually be carried out?

The answer is no. The Gramm-Rudman threat will not be carried out regardless of whether the courts rule that it is constitutional or unconstitutional. We are not going to shut the federal prisons and unilaterally disarm. The president and Congress are going to play a giant game of chicken between now and October 1. Each will talk tough and hope that the other will swerve and bend to their will. But if neither swerves, they will find some way to avoid implementing the budget cuts they are now promising to implement.

Perhaps such threats are made in the hope of forcing our national leaders to act sensibly. But it is hard to find any examples in human history where stupid threats have persuaded anyone to act sensibly. As any course in military strategy teaches, stupid threats work only if you convince the other side that you really are a crazed person and would blow up the world with yourself on it. Neither the president nor Congress is crazed and thus neither side is going to believe the other's threats.

The real stumbling block to budget balancing is taxes. As a fraction of GNP, U.S. government spending—at the federal, state, and local level—is now the lowest among all the industrialized countries. With only a small defense budget, Japanese governments still spend slightly more than American governments. All other in-

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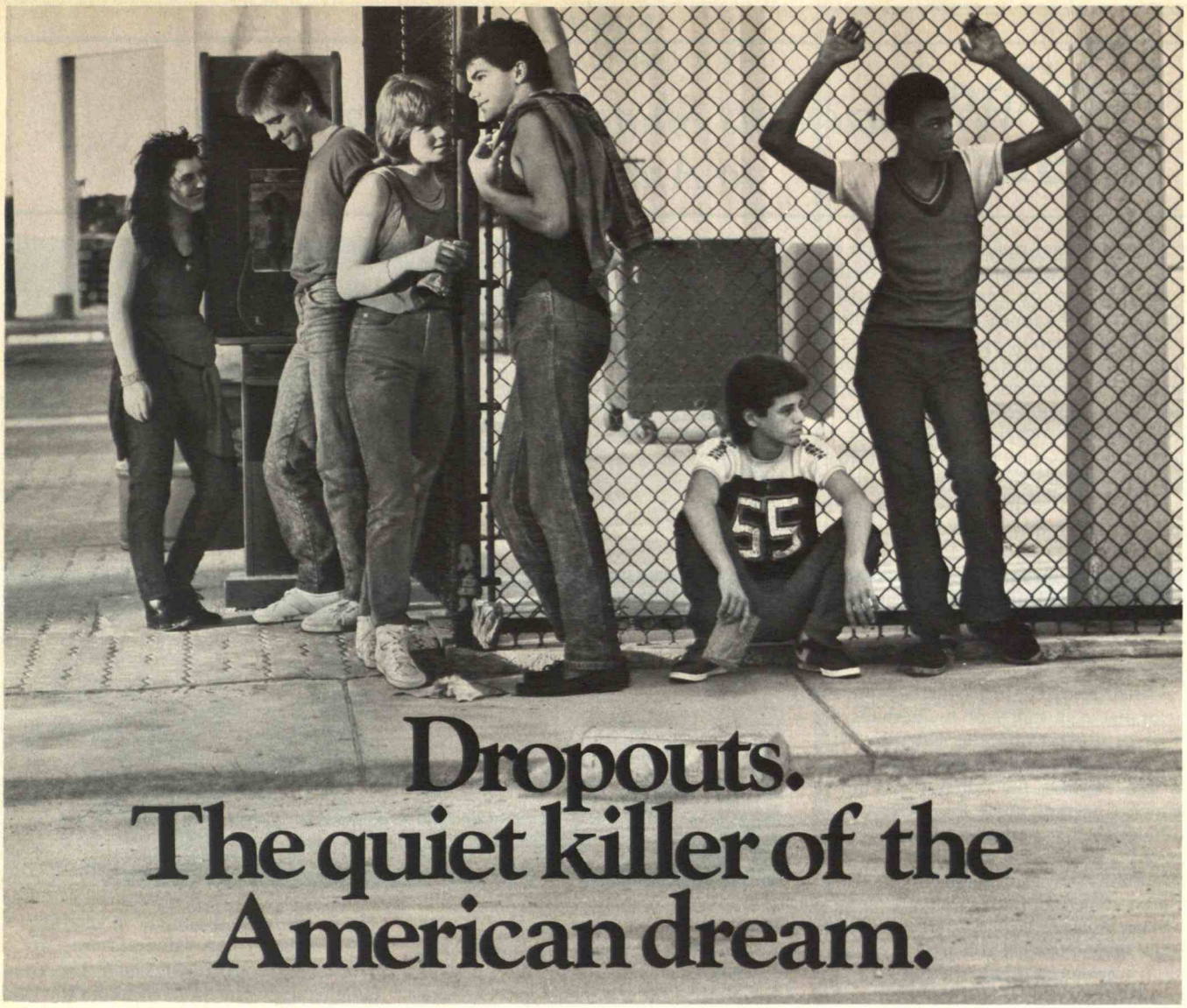
ILLUSTRATION: BRUCE MADDOCKS



Dropouts. The quiet killer of the American dream.

Once a dilemma. Now a crisis.

Thirty percent of America's teenagers aren't graduating from high school. That's three quarters of a million dropouts each year.

In our large cities — Boston, New York, Detroit, Chicago, Washington and Philadelphia — the dropout rate is 35-50%.

The cost to society of the dropout crisis is staggering. More than half of the nation's prison inmates are dropouts — and it costs taxpayers up to $25,000 a year to house a prisoner in a correctional institution. That total is higher than the cost of a year of education at either Harvard or Yale.

The Business Advisory Commission of the Education Commission of the States recently called on all of society — business, schools, civic organizations, labor and professional groups — to address the dropout problem. We as a nation cannot let one quarter of America's youth continue to drift toward hopelessness.

That's why the National Education Association has initiated a major new effort to rescue young people from academic failure. NEA has committed $1.7 million to this effort — one dollar for every NEA member. We will devote $700,000 to this war-chest against scholastic failure to Operation Rescue, our new program to combat the dropout and illiteracy syndrome.

The remaining $1 million will establish an endowment to make educational excellence grants available to teachers for years to come. And we're asking other concerned groups — both inside and outside education — to join teachers in building this fund. Our aim is to begin funding local dropout prevention programs by the fall of 1986.

Our goal with Operation Rescue? We want to help cut the dropout rate in half by 1990.

Our goal as an association? In over 128 years, that's never wavered. We stand for excellence in every classroom, for every child.

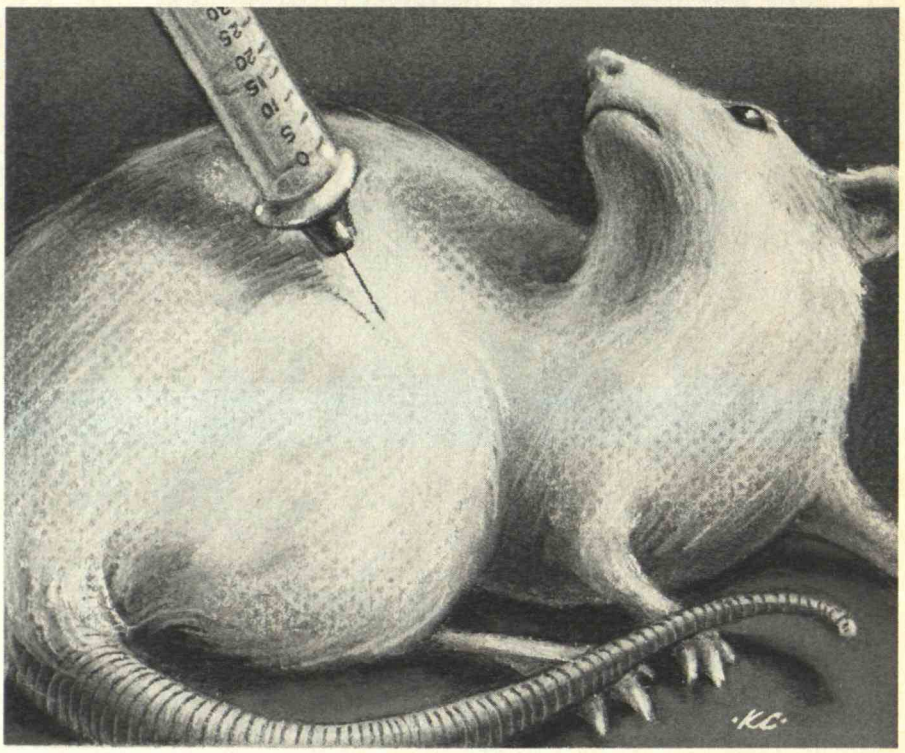
nea

National Education Association

THE SUBJECT IS EXCELLENCE

BY ANDREW N. ROWAN

Why Scientists Should Seek Alternatives to Animal Use



THE animal rights movement, a coalition of groups dedicated to eliminating or reducing people's exploitation of animals for food, clothing, sport, and research, has become a major social force. In Australia, a Senate Committee of Enquiry on Animal Welfare recently recommended that the capture of dolphins for marine aquariums be stopped, not because the species is threatened but because such capture is unwarranted exploitation of dolphins. In England, the underground Animal Liberation Front launches daily raids on butcher shops, fur farms, and research laboratories. In the United States, heightened public concern for animals is reflected in movies such as *E.T.*, *Greystoke*, and *The Secrets of NIMH*.

Animal research, in particular, touches a raw nerve in many of us, perhaps because of our unconscious empathy with the helplessness of laboratory animals. In the last ten years, the animal rights movement has become much more effective in stimulating that nerve—with graphic ads on subways and in magazines—and is mounting a serious challenge to the use of at least some laboratory animals.

Many research scientists view any campaign against animal research as an abolitionist attempt to halt the practice. Yet those who seek the immediate elimination of all animal research represent only a small proportion of the public—albeit a vocal and committed one. A recent referendum in Switzerland calling for an end to all vivisection (animal research) was supported by only 30 percent of those voting (not more than 10 to 15 percent of all registered voters). Opinion polls in the United States and England indicate that support for the hard-core abolitionist position runs at around 15 percent.

However, large segments of the public can be mobilized to oppose what they perceive as cruel and unnecessary experiments. For example, a number of media commentators, including Paul Harvey and James Kirkpatrick, were horrified by a videotape distributed by People for the Ethical Treatment of Animals (PETA) illustrating head-trauma research done on baboons in a University of Pennsylvania laboratory. PETA produced the video from material confiscated by underground activists during a raid on the lab. Even though the raid was illegal, lab violations found as a result have led the government to suspend funding for that program. Animal rights advocates have also run successful campaigns against the use of animals for testing the safety of cosmetics and other consumer products.

Public concern seems to focus on the extent of animal suffering, the manner in which research is conducted, and the purpose of the research. For example, most people would probably not favor the use of animals to produce a new shampoo. At the same time, many people seemed willing to countenance the killing of a baboon (if painless) to provide a surrogate heart for Baby Fae. In fact, we will probably always be willing to accept the death of an animal for some immediate human benefit. (Personally, I think the Baby Fae case was a needless waste of the animal's life and an unfortunate experiment that merely prolonged a human infant's suffering.) The public also seems to accept the fact that certain types of research, particularly clinical research on cancer and heart disease, require the use of animals.

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The Power of Alternatives

The animal rights movement has campaigned aggressively to promote the idea that the use of animals could be eliminated if other research techniques were developed. I believe that government should fund more efforts to develop and promote techniques that will replace or reduce animal use and suffering. Yet most scientists tend to be very suspicious of this concept. Perhaps they confuse the message with the messenger.

Alternative research methods have been of major value in expanding scientific knowledge as well as in developing new health therapies. The development of a polio vaccine first became a realistic possibility when three American scientists showed that the polio virus could be grown in human cell culture—that is, in a test tube.

Vast new avenues of biomedical research were also opened with the development of two other in vitro techniques: radioimmunoassay and hybridoma technologies. The former involves attaching a radioactive label to an antibody, which is produced by the immune system to seek out foreign molecules. Scientists can use

ILLUSTRATION: KEN CONDON

this technique to measure specific compounds—for example, the sex steroids in blood—and to correlate these measurements with human reproductive function, or lack of it. The new hybridoma technology involves fusing an antibody-producing cell with a cancer cell, taken from a tumor grown in mice. The result is a cloned "hybrid" cell that will grow forever (at least in theory) and produce antibodies in a test tube. This technique enables scientists to produce large quantities of monoclonal antibodies—pure antibodies that bind to specific molecules. Monoclonal antibodies are now being used to diagnose many viral and bacterial diseases and are also being tested for use in new cancer treatments.

Radioimmunoassay and hybridoma technologies allow scientists to do much more with fewer animals, because the techniques are so sensitive that many measurements can be carried out on small quantities of biological material. Molecular biologists are also developing new techniques to produce monoclonal antibodies from cancer cells grown in culture instead of from tumors grown in mice. Such cell cultures will eliminate the need for millions of "mouse factories."

The scientists who discovered that the polio virus could be grown in cell culture as well as the developers of the radioimmunoassay and hybridoma technologies, all won the Nobel Prize because they came up with powerful new techniques. Yet there is little explicit support for developing new techniques. Investigators seem to be more attracted to the possibility of making a conceptual breakthrough than to developing a new technique. Indeed, the scientific establishment has shown positive antipathy toward the concept of new alternative techniques.

Bias against Unconventional Methods

New legislation, specifically the Health Research Extension Act of 1985, now requires the National Institutes of Health (NIH) to establish a program to develop such alternatives. The NIH has made some tentative moves in this direction. For example, the NIH supported a National Academy of Sciences (NAS) study on the potential for non-traditional techniques. The study concluded that as biological understanding shifts more and more to the molecular level, there is less need to use models closely related to human biochemistry and physiology—i.e., mammals.

Harold Morowitz, a Yale University professor who directed the NAS study, reported anecdotal evidence that investigators who use unconventional models have difficulty getting funded. While the study report did not directly criticize the funding patterns of NIH, it did urge the government to support research "without taxonomic or phylogenetic bias." It also recommended that NIH redirect funds specifically for developing promising new model systems.

The use of animals in research laboratories has fallen dramatically in recent years. In England, animal use has dropped 35 percent over the past ten years. This decline is due to the increasing use of alternatives as well as the elimination of unnecessary animal use. In Switzerland, the three large drug companies—Sandoz, Ciba-Geigy, and Hoffman-LaRoche—have cut their use of animals from 2.7 million annually in 1977 to 1.5 million in 1984. In the United States, the cosmetic and chemical industries have discovered that they can save substantial amounts of money while reducing their use of animals. In most cases, savings have come from eliminating unnecessary tests, but many companies are replacing the classic acute-toxicity test that requires 40 to 200 animals with another that uses only 10 to 20. Companies are also exploring new techniques using chick eggs and invertebrates that may further reduce animal use. Some companies report a 75 percent reduction in animal use.

Under the new NIH legislation, a special committee at each research institution is required to review animal research projects requesting NIH funding. This new policy will focus attention as never before on efforts to reduce animal use and suffering. It could promote a mindset among research scientists that will encourage them to develop and use alternatives.

This is not a disaster for science, as some traditionalists would argue. It is an opportunity to show that science can be socially conscious as well as innovative and exciting. Focusing more attention on alternatives will not eliminate abolitionist activity or animal research. However, I believe that such an effort will produce a public more willing to support the animal projects that are still required. It may also lead to more Nobel Prizes. □

BY DANIEL KLEPPNER

Is U.S. Science Slipping from First Place?

In the mid-1950s I joined the ranks of undergraduate physicists at Cambridge University, one of the lucky Americans studying abroad on a Fulbright fellowship. Although Britain was just then emerging from a long postwar austerity—food was still being rationed—confidence and hope were in the air. The spirit of Maxwell, Rutherford, and other legendary physicists was tangible at Cambridge. For our radioactivity experiments we were solemnly handed ionization chambers made by Rutherford's own hands. The public debuts of the Rolls Royce turboprop engine and the Comet jetliner proved to all that the British had not lost their engineering genius. Britain's vast cultural heritage, its industrial and military power, and above all its political institutions exuded confidence that much better times lay ahead.

Looking back, one cannot help feeling sad that Great Britain has fallen so short of those expectations. Her standard of living has sunk below that of most other European nations. British institutions from education to medical care are facing disarray, and British scientists are slowly but surely losing their battle to stay in the front ranks of research. Of the many factors responsible for this decline, one stands out with all the clarity that only hindsight provides: the British confidence that was so exhilarating in the 1950s included a disastrous component of complacency.

The United States has been the world leader in science for so long that it seems inconceivable that we, too, could be on the verge of falling back. However, since the early 1970s federal support for university science has lagged behind the needs of first-rate research. Today one can see signs of growing distress in the universities. Facilities are outdated, equipment is largely obsolete, and the infrastructure of shops and specialized support services needed for competitive research has deteriorated. University careers, once coveted by young scientists, have become visibly less attractive, so much so that in some fields the universities are unable to fill vacancies. This deterioration will only accelerate if federal support is cut further under Gramm-Rudman. The universities are at the heart of science in the United States; if they falter we will inevitably slip from the first rank.

The price the United States stands to pay for ignoring the universities' distress signals is heavy. There will be a shortage of scientists able to generate the advanced knowledge needed to secure new forms of energy, protect the environment, and solve the myriad of scientific problems that arise in modern society. We will miss out on the advanced technologies that are needed for economic strength and national security. Our standard of living will inevitably decline.

The Dilemma in Physics

The problems facing university-based research are roughly the same throughout the physical sciences. I will draw on information about my own field—physics—to describe these problems. Roughly half of the federal support for physics in the universities comes from the National Science Foundation. The remainder comes from mission agencies such as the Department of Energy, the Department of Defense (DOD), and NASA. The commitment to basic research by these agencies depends on their long-range views—views that have often wavered. For ex-

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ILLUSTRATION: BOB DAHM

It's hard to blame young scientists these days for taking jobs in industry rather than in universities.

ample, in the years following World War II, the principal federal agency for the support of U.S. physics was the DOD. Its guiding principle was that in the long run, good physics was good for the nation and good for DOD. Under the DOD's enlightened support, physics started to flower in the United States.

In 1958, spurred by the humiliation of Sputnik, President Eisenhower ordered a massive scientific buildup. Congress passed the National Defense Education Act—a four-year $887 million (1958 dollars!) program of student loans, fellowships, and other aids—and expanded the role of the National Science Foundation. Between 1960 and 1970, the physics faculties of U.S. universities practically doubled in size, and the number of Ph.D.s awarded each year in the field soared from 530 to 1,650.

This buildup stopped abruptly at the end of the 1960s as the nation struggled with the Vietnam crisis. In 1969 the DOD pulled out of basic research under the force of the Mansfield amendment. This law limited the DOD to supporting only research that was immediately tied to DOD objectives. Responsibility for basic research was transferred to other agencies, but no provisions were made for a transfer of funds. Thus, the support was simply lost. The Mansfield amendment was on the books for only one year, but the DOD never resumed serious support for basic physics.

Recent claims by the DOD that it is once again supporting basic research are misleading, as even a cursory glance at funding citations in the prestigious *Physical Review Letters* will reveal. Funding for research connected to the Strategic Defense Initiative is mostly in engineering and the applied sciences; the component of basic research essential for success in any such long-range technical program is missing. Support for university-based research dropped so precipitously during the early 1970s that in spite of recent increases, funding remains inadequate. Essentially, the nation is living on the investment in science that it made in the 1960s, and the dividends are starting to run out.

At the same time, there is growing concern in Congress about the high costs of physics in the United States. For the most part, the debate centers on the cost of major facilities such as large telescopes and accelerators for elementary particle physics. In particular, the $5 billion price tag of the proposed Superconducting Super Collider (SSC), an accelerator whose circumference is 100 miles, dominates most discussions about the overall level of federal support for physics. Compared with previous scientific facilities, the cost of the SSC is unquestionably high. However, such a project should not be judged in the context of physics research alone, but in the context of national programs such as the hypersonic plane and the permanent space station. These programs are justified by considerations of national prestige and long-range economic returns. By these criteria, the cost of the SSC is not high.

The Value of Small-Group Physics

Unfortunately, the debate over the SSC obscures the fact that most basic research is actually carried out by small groups—perhaps as small as a single professor with one or two students—working with equipment in their own laboratories. Such groups train approximately 70 percent of our Ph.D. students, contribute broadly to other sciences, and generate new technologies for a host of applications.

For instance, the largest field of small-group research in universities is condensed-matter physics. Once known as solid-state physics, this research underlies knowledge about the structure of matter from superconductors to polymers, and it is fundamental to all efforts to create new materials. From research on semiconductors (much of it in industrial laboratories) has come modern electronics and with it, the computer revolution.

Next in size is atomic, molecular, and optical physics, a field that spans problems from the basic structure of space and time to how electrons rearrange themselves during a chemical reaction. From this type of basic research has come the laser and modern optics. Today lasers are used in practically every area of science, in hospital operating rooms, in environmental monitoring stations, and in factories.

Small-group physics is obviously a major force in science. Yet support for such research is languishing. Perhaps this is because it is harder for scientific administrators to make the case for broad support of small research groups than for a monumental new project such as an accelerator. It is more fun to launch a new facility than to sustain an old program.

With the cutbacks in science during the early 1970s came a cutback in university hiring. The appointment rate has remained low for so long that our science faculties have aged dramatically. The median age of physics faculties, for instance, has climbed from 39 years in 1970 to 49 years today. In the next decade, our physics faculties will start to retire at an accelerating rate, creating a sharp increase in the number of vacancies.

But who will fill them? A major survey on physics just released by the National Research Council (NRC) points to a shortage of qualified scientists to fill faculty vacancies. In some fields, universities are *already* having difficulty filling positions, even though the actual number of faculty positions remains small. Until recently, for instance, faculty positions were coveted in the area of experimental condensed-matter physics. Now even leading physics departments report that there is a pronounced shortage of qualified candidates in this field. The best are taking jobs with industrial laboratories instead. This situation is particularly worrisome because industrial and federal laboratories depend on the universities to educate an adequate supply of young scientists for their staffs.

Salaries in academia have always been lower than those offered by industry. In spite of this, many of the best young condensed-matter physicists chose university careers until recently. The change in attitude fundamentally reflects the changing conditions at the universities themselves.

Inadequate funding is an overwhelming problem. Young scientists setting out on university careers today face the prospect of waiting several years to obtain federal research support, and then having to make do with grants that are too small for competitive research. The average research grant to a university experimental physics group is about $85,000, yet the annual cost of maintaining an active research group is between $200,000 and $400,000. New equipment is inevitably squeezed out of the budget because of the overriding need to support students. For example, molecular beam epitaxy—a technique that makes it possible to create materials found nowhere in nature by building them layer by layer at the atomic level—is largely missing from university laboratories. It simply costs too much.

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MANAGING TO KEEP RIVERS WILD

Built to tame rivers and generate power, America's grand dams are hurting fish and plant life downstream. Dam operators are adopting new technologies to reduce the damage.

BY TONY DAVIS

"MAN has flung down a great barrier in the path of the turbulent Colorado in Arizona," proclaimed the U.S. Bureau of Reclamation during the 1960s. "It has tamed the wild river—made it servant to man's will." The bureau was boasting of Glen Canyon Dam, a 710-foot-high monument to technological prowess, but it could have been talking about any dam in the country. Virtually every major U.S. river has been hitched to a dam, making the regulated river this country's most common riverine habitat.

The construction of concrete monoliths like the Hoover Dam on the Colorado River at the Arizona-Nevada border, and the Bonneville Dam on the Columbia River at the Oregon-Washington border, began in the Depression. The federal government promised that in addition to creating construction jobs, the dams would control floods, generate electricity, and store water against droughts. Today the public reaps these benefits but is also beginning to recognize the costs. The large dams significantly disrupt fish and plant life downstream and may eventually hurt tourism in the canyons below the dams. The agencies that operate them are facing the heavy costs of modifying the structures to lessen these effects and restore damaged ecosystems.

Consider the Glen Canyon Dam. You could argue that it has done more than any other public-works project to transform the Southwest into the Sunbelt. By storing more water in its reservoir, called Lake Powell, than half the U.S. population consumes in one year, the dam is insurance against droughts. Equally vital for the area's development, the dam's turbines churn out enough electrical power for a city the size of Phoenix. Lake Powell is also a mecca for recreation, drawing 2.2 million visitors a year for boating and other water sports.

But the dam has drowned Glen Canyon, a naturalist's paradise of red sandstone, and environmentalists have nicknamed its reservoir Lake Foul—more in disgust at the loss of the canyon than because of pollution. Now ecologists from national groups such as Friends of the Earth and Friends of the River charge that downstream toward the Grand Canyon National Park, the dam is slowly destroying the delicate web of life along the river. Ecologists have learned that because the dam has lowered the temperature of the water downstream, four native fish species have been wiped out. Recreationists suspect that by holding back sediment that used to replace what natural erosion removed, the dam is slowly destroying beaches that provide camping spots in the Grand Canyon. In 1983 the nearby community watched a flood, caused in part by poor management of the dam, wipe out thousands of trees along the river's banks.

Not all the changes caused by the dam are for the worse. For example, the colder river water that destroyed the native fish nurtures a population of cold-water trout introduced from a blue-ribbon hatchery. By reducing the volume of the river's flow, the dam has allowed trees to grow along the river's banks. Still, concerns are serious enough that the U.S. Bureau of Reclamation, which built and oversees the dam, launched a $4 million study of its effects on the canyon. A team of researchers from five Arizona state and federal agencies and three universities will deliver their results in 1987. If these scientists find merit to the charges, the bureau will almost certainly consider making major changes in the way it operates the dam.

In other parts of the country, dam operators—under pressure from environmental groups—are already implementing changes to keep their rivers healthy. In the South, the Tennessee Valley Authority (TVA) is spending about $8 million to retrofit its dams with devices that will in-

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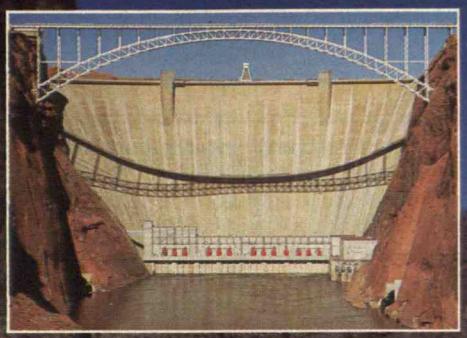
PHOTOS: TERRENCE MOORE FROM TOM STACK ASSOC.; JOHN RUNNING



Grand old dams, like Hoover Dam (the Nevada Spillway shown here) and the Glen Canyon Dam (insert), have helped transform the Southwest into the Sunbelt.

By eliminating the river's natural flooding cycle, large dams disrupt fish and plant life as well as tourism downstream.

crease the river's oxygen level, depleted by the structures, to try to bring back the fish. In the Northwest, where dams generate low-cost electricity for half the region's populations, the Bonneville Power Administration (BPA) is spending up to $30 million a year to modify those dams so that migrating salmon do not get caught in the structures' turbines. (The BPA sells and distributes the power these dams produce, but the Army Corps of Engineers and independent public utilities operate them.) "It took us 80 years to get into this fix," says Sharon Blair, spokeswoman for the BPA in Portland, Oregon. "Who knows how many years we'll need to get out of it?"

A Chilling Effect on Fish

Once you build a dam, what happens over the next decades depends on the dam's purpose and how well its design and operation match the ecology of the river. For example, the location of the dam's intake structures, openings that channel the river's water through the dam, can so adversely affect the river's temperature and oxygen levels downstream that fish will not survive. The Shasta Dam on the Sacramento River near Redding, Calif., has its intake structures halfway beween the river's surface and bottom. In warm, dry years, the river is low and the water from the surface of the heated river flows through the dam. This water, only 2 to 4 degrees warmer than the bottom water, is still warm enough to kill salmon eggs incubating in downstream gravels.

The intake structures of the Glen Canyon Dam are at the bottom of its 568-foot-deep reservoir. All year round, 48-degree water from the chilly bottom of Lake Powell streams through. Before the dam's completion in 1963, the temperature of the water in the hot Arizona sun averaged 75 to 80 degrees in the summer months. The dam now supports only four species of native warm-water fish compared with eight before the dam went up. The remaining fish depend on the river's warmer tributaries as breeding grounds.

In the Tennessee Valley, where the TVA's 27 dams generate electricity and control floods, operators release water only when the reservoirs reach capacity. This creates a problem known as eutrophication, a biological aging process. In the still water, nutrients, sewage waste, and other improperly treated organic materials react with oxygen, gobbling up the supply needed by the fish. The dam's intakes are at the bottom of the reservoir where the greatest eutrophication occurs. Thus, the downstream water carries only one part per million of oxygen, even though the fish need five to six parts per million to thrive. This shortage forces the oxygen-starved fish to travel from one to forty miles downstream in search of oxygen-rich waters.

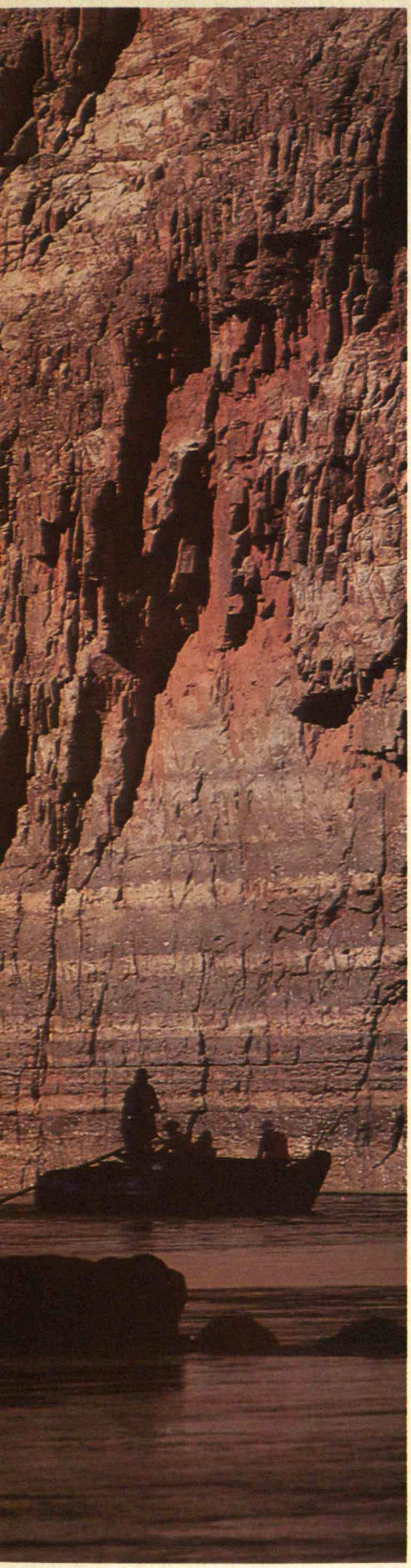
Dams also raise unnatural obstacles for fish that spawn in the river and mature in the ocean. For example, their structures slow down the natural speed of the river, especially in reservoirs. The 60-odd dams on the Columbia River affect the progress of young salmon and steelhead trout, which migrate downstream to the ocean on a deadline. Thirty days after the fish begin the journey, their metabolism changes. If they haven't reached the ocean by then, they'll never mature and return to spawn. The reservoirs can increase a fish's typical trip from two weeks to more than six.

A dam's turbine presents the greatest physical danger to fish. Rotating blades, large enough for a human to stand inside, chop up fish. The spinning blades create a partial air vacuum, and the water's pressure changes may be strong enough to stun or knock out smaller fish. Those that do survive offer downstream predators easy targets.

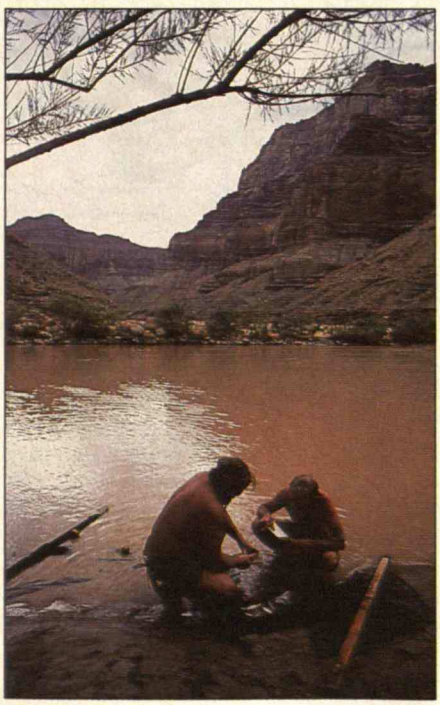
The Drying River Beds

By far the biggest change that dams bring to a river's environment results from the fact that they eliminate the natural flooding cycle on which a host of animals and plants depend. In *Impounded Rivers,* Geoffrey Petit noted that willows began to grow downstream from dams on several northern California rivers because the regulated river no longer flooded its banks. The willows encroached on salmon spawning beds, depressing fish populations.

In northeastern British Columbia, the W.A.C. Bennett Dam has altered the natural flood cycle on the Peace River. Because the dam regulates the river's flow, the river no longer floods downstream the way it used to. The victim has been the rich freshwater delta in the 17,000-square-mile Wood Buffalo National Park in Alberta. The delta is on a migratory route for four North America waterfowl; it is



Left: Ecologists charge that the Glen Canyon Dam has aggravated erosion in the Grand Canyon by holding back sediment and creating yo-yo-like fluctuations in the level of the Colorado River. Below: In Alberta's Wood Buffalo National Park, sedge meadows are drying up because the Bennett Dam blocks the flooding of the Peace River. At risk are one of the world's largest herds of wood bison and a colony of endangered sand hill cranes. Bottom left: Glen Canyon Dam lowered the Colorado River's temperature enough to wipe out four species of native fish. Scientists examine a dead humpbacked chub, one of the affected species.



PHOTOS: JOHN RUNNING; PATRICK McCLOSKEY; ED STRUZIK; CLEVE WERSHLER

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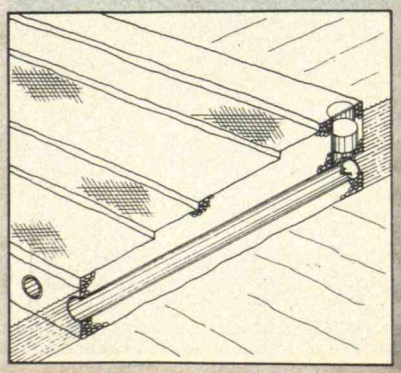


E

Steelhead trout (below) routinely try to leap over Prosser Dam on the Yakima River in Washington, and many of the fish don't make it. A number of dam operators have instituted technologies designed to save freshwater fish. The Bonneville Power Administration uses a fish screen (A) at Cowiche Dam on the Naches River in Washington to steer fish away from the deathtrap of the turbine's blades. Migrating salmon and steelhead climb the gently sloping ladders at Roza Dam (B) (here not in use) and at Waputo Dam (C) to spawn upstream on the Yakima River. On the Clinch River in Tennessee, where the Norris Dam so slowed the river's speed and depleted its oxygen that fishers weren't catching any fish, the Tennessee Valley Authority built a five-foot-high rock weir (D). This creates enough of an obstacle to accelerate the river's flow. Inside the weir (E), 54 12-inch-wide pipes divert the water, also increasing the river's speed.

Thanks to the Glen Canyon Dam, little that lies along the Colorado River is truly natural.

also home for one of the world's largest herds of wood bison. Yet it has begun drying up because of the lack of flooding. Robert Redhead, the park's chief warden, says a field of sedge meadows that protects the bison and waterfowl is losing ground to willow trees. Bison counts have dropped from 10,000 in the early 1970s to 5,000 today, although Redhead notes that disease has probably taken a toll. If current drying trends persist, Redhead warns, aspens and conifers—denizens of still drier habitats—will move in.

The Glen Canyon Dam has eliminated summertime floods on the Colorado River that once reached 100,000 cubic feet per second by restricting flows to no more than 31,000 cubic feet per second. According to researchers at the University of Arizona, this lack of flooding is changing the downstream flora—but not necessarily in negative ways. Tamerisk, acacia, seep, coyote, willow, and an occasional mesquite are sprouting along the river bottom. The trees have drawn 4 new bird species and sent populations of 30 to 40 others skyrocketing. Yet the low flows have also cut off nourishment to mesquite and acacia on the canyon's old high-water line 250 feet above the river.

By holding back water, the dam also holds back sediment that once restored beaches washed out by natural erosion. Biologist Larry Stevens has predicted that one-third of the remaining beaches will be gone in 15 years and that 90 percent will be gone in 75 years. Another study by geologists at Northern Arizona University shows that a gradual, long-term erosion of 25 beaches downstream occurred between 1974 and 1985. Yet still another study of the same beaches done by two environmental scientists at the University of Virginia found little loss to erosion. None of the studies are definitive because they cover only 25 of the canyon's 200-plus beaches. Thus, long-term trends remain uncertain.

Operators of dams that generate electricity raise and lower the river's level according to the public's consumption of power. The operators send high water through the dam's turbines during morning and afternoon peak hours for electricity demand, and send low water—sometimes as little as 3,000 cubic feet per second—during off-peak hours. This system brings in more money to repay the costs of building the dams because there is more power to sell when people want to buy it. The practice also benefits utilities who buy the power and their customers, who would otherwise have to purchase higher-priced peak power derived from oil or gas. But environmentalists from Friends of the River and Friends of the Earth claim that the yo-yo-like fluctuations in water levels aggravate erosion. "The high water soaks the beaches, and they collapse when the water goes down," says Gaylord Stavely, who is owner of a Flagstaff rafting company.

Tarnished "Jewel" of the Colorado

Dam builders failed to take most of these ecological disruptions into account when they designed the structures. Most dams went up long before 1970, when the National Environmental Policy Act first required environmental impact statements for new, major water projects. Dam builders' major mistake was to assume that a dam could serve several functions simultaneously without slighting any of them.

A Bureau of Reclamation pamphlet entitled "Lake Powell, Jewel of the Colorado" promised that the Glen Canyon Dam would end both floods and droughts and bring direct or indirect benefits to nearly every U.S. citizen. However, the first two tasks often conflict. A well-operated flood-control dam keeps the water level in the reservoir as low as possible to catch heavy and unexpected runoff. A well-operated water storage dam is as full as possible to guard against the droughts that haunt the West every few years.

This contradiction became apparent in 1983 when record spring snows melted and streamed into an already full Lake Powell, forcing the bureau to release up to 96,000 cubic feet of water per second through the Grand Canyon. The flood took away what the dam had given, wiping out from 16 to 70 percent of four species of trees and from 47 to 100 percent of the nests of three species of birds. The high water did give new life to the aging mesquite and acacia trees above the river: trees that had been going dry for two decades grew several inches. It also gave a fresh coat of sand to many of the canyon's beaches, pulling sediment off the river bottom and upper canyon beaches and dumping it on those in the lower canyon. But the new sand proved an unstable gift. One year later, National Park Service studies showed that the new sand had already eroded.

The flood, which caused tens of millions of dollars in property damage to downstream cities and $30 million in damages to the dam itself, brought the bureau a storm of protest. Critics accused the bureau of failing to foresee the problem in time to release water from Glen Canyon and other dams. Critics also accused the bureau of emphasizing water storage at the expense of flood control. Under pressure from state water resource agencies whose job is to ensure an adequate water supply, the bureau had deliberately kept Lake Powell and other reservoirs full or nearly full, leaving little breathing room.

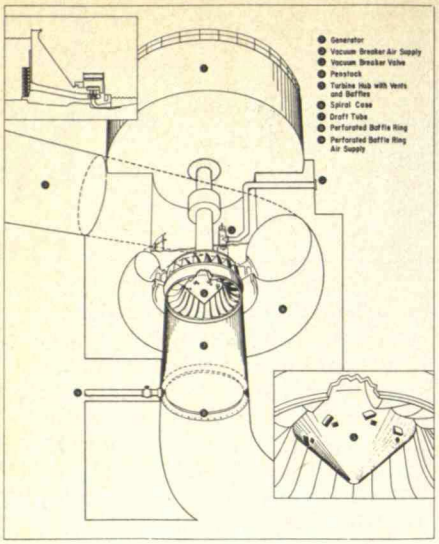
A year later, the Colorado River actually got more spring runoff than in 1983. Yet the snow fell earlier than before, giving the bureau more time to lower the reservoirs. The high water caused virtually no damage and many Arizona officials praised the bureau for its foresight. Few noticed that the agency's underlying policy of keeping the reservoirs as full as possible had not changed. Although the agency is now far more attuned to the possibility of a flood, officials acknowledge that another high-water year like 1983 could bring the same destructive results.

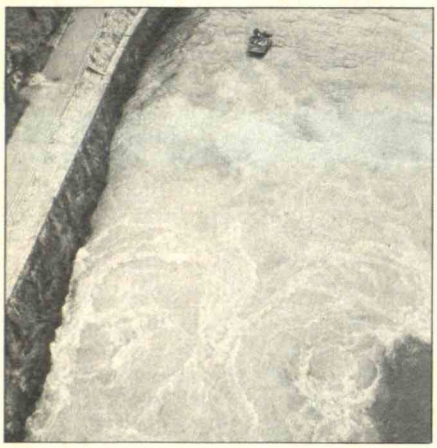
Whatever a dam's functions—generating power, storing water, or controlling floods—environmentalists are now arguing that these should not interfere with the river's plant and animal life. However, it is not easy to change the way a dam is operated, since the web of vested interests becomes as complex as the river's ecological relationships.

For example, if the bureau's study proves that the Glen Canyon dam is indeed eroding the Grand Canyon beaches, operators could reduce the fluctuation in the water releases. The backers of this idea believe that the bureau could obtain the income it needs without running a peak-power operation by raising rates to match those charged by privately held utilities. Although such a move would cut against the grain of federal policy that has prevailed since the Great Depression—that of promoting low-cost hydropower—the idea is not unthinkable. In 1983, a similar scheme proposed for the Hoover Dam lost by 40 votes in the U.S. House of Representatives. Federal officials successfully argued if they charged market rates, consumers would have to pay higher electric bills.

If the bureau's study shows that the habitat of trees and birds needs to be protected

PHOTOS: BOB TUCK; TVA





To boost oxygen levels for fish, the Tennessee Valley Authority attached metal baffles to the turbine blades at Norris Dam. By creating negative air pressure inside the turbine, the baffles send aerated, oxygen-rich water churning through the tail race (center). Without the baffles, the water in the tail race is oxygen poor (bottom). Facing page, top: The Colorado River in 1982. Below: One year later, a flood that environmentalists say was caused by poor dam management wiped out thousands of trees and shrubs along the River's banks.

from further destruction, the bureau could store less water behind the dam to guard against future floods. The bureau could especially try to avoid floods in late spring, the peak nesting season. But the states that actually own the river and advise the bureau on how to run the dam are reluctant to allow operators to tilt toward flood control even in the wet season. In the eyes of these states, any water that is released in the name of flood control is wasted.

If the bureau's study supports the idea of bringing back the native fish, the operators could modify the dam's intakes and raise the water temperature. But bureau officials suggest that this could prove counterproductive. If the water gets warmer, the warm-water striped bass introduced years ago to Lake Mead at Hoover Dam might swim upstream and attack the smaller native Grand Canyon fish. "It is a very complex piece of environment down there," says one bureau official. "You can't say modify the temperature and fix everything."

Some scientists question why the government should even bother to protect trees that used to be flooded annually by nature. This issue is especially knotty because floods that hurt the plants on the river bottom help the acacia and mesquite trees above the canyon floor. Moreover, by law, the National Park Service must protect the natural environment inside its boundaries. However, thanks to Glen Canyon Dam, little that lies along the river banks of the Grand Canyon is truly "natural."

Technologies That Save Fish

Officials at several other dams are already modifying their design and operation to bring back fish populations, and initial results look encouraging. When the Bonneville Dam was constructed in the 1930s, scientists thought that salmon and steelhead trout could pass through the turbines without any problem. According to Dale Evans, chief of the Environmental and Technical Services Division of the National Marine Fisheries Service in Portland, fish losses did not become serious until the 1960s. Before that the river's natural flow far exceeded what the dam's turbines could handle, so water spilled over and around the dams, carrying the fish safely along. During the drought of 1977, the public realized there was a crisis, and Bonneville Power trucked the fish around the dams. Of those left behind in the Snake River (which drains into the Columbia), 98 percent died.

In 1980, fears for the future of the salmon and steelhead trout prompted Congress to pass legislation creating the Northwest Power Planning Council. The council established a water budget program, in which fish and wildlife supporters and hydropower interests negotiate a guaranteed minimum flow to insure that the salmon reach the sea. The council ordered the Bonneville Power Administration to begin the lengthy and expensive process of changing their turbines so they don't act as death traps.

The most promising such modification is fish screens, which divert the fish away from the turbines' dangerous blades. Outside the dam a metal screen forces fish into special intake openings, while inside the dam large wire mesh screens weighing as much as 30 tons protect the fish from the turbine blades. The council has ordered the Army Corps of Engineers and three public utility districts to put screens on eight of their dams. Until they are in place, the agency is supposed to spill enough water over the dams or truck the fish around to insure that at least 90 percent survive.

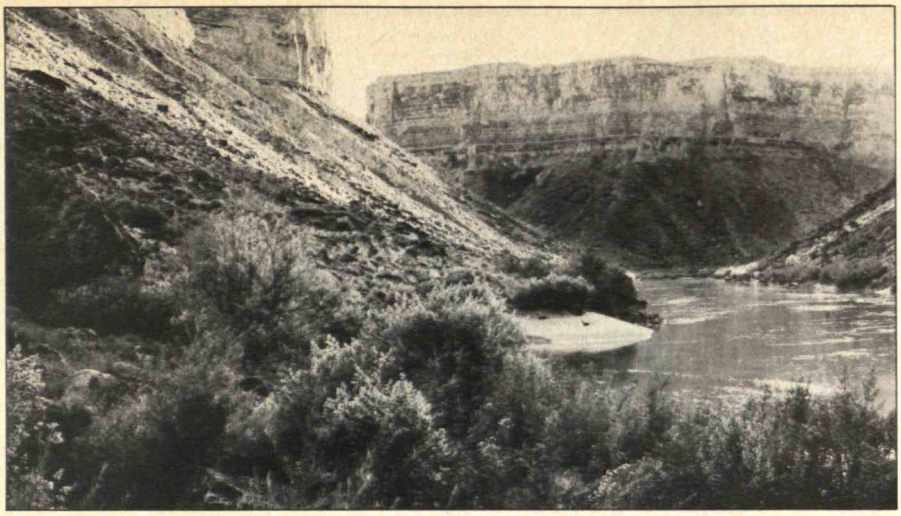
Screens have so far been installed at only five BPA dams. However, the screens installed in 1984 at Bonneville Dam's 10 new turbines do not work, although no one is sure why. One theory is that the currents immediately in front of the dam's powerhouse create a downward-moving eddy effect, pushing the fish below the screens. The screens are big enough only to cover about the upper third of the 60-foot-deep turbine intake structure. By tracking the fish with sonar, the BPA found that the first screen diverted 25 percent of the fish population instead of the 85 percent they had hoped for. Bonneville was forced to shut down to keep the rest of the fish out of the turbines for two months.

Despite this setback, the council's program has proved successful. In 1985, the council reported that fish populations heading upstream to spawn have increased dramatically since the recovery program began three years ago. Fall Chinook salmon and steelhead trout runs at Bonneville and McNary Dams on the Oregon-Washington border were at their highest levels since records were first kept in the 1930s.

The Tennessee Valley Authority has also boosted its fish population by modifying its dams. At the Norris Dam on the Clinch River near Knoxville, the TVA installed metallic hub baffles—fan-shaped pieces of pipe that fit at right angles against the holes of the propellor-shaped turbine blades. As the propellors spin the baffles create negative air pressure, drawing more oxygen into the water. TVA built steel and rock structures called weirs downstream from the dam that back up water and increase river flows immediately below the dam. Such devices help raise the water's oxygen level.

After two years of using both methods,

PHOTOS: TVA



agency researchers are observing more and greater varieties of the organisms fish eat. Last fall, after Tennessee officials stocked the downstream river with trout, fishers were reportedly catching .81 fish an hour. Before the weirs and baffles, they weren't catching anything even though the stream was stocked. The agency has installed similar modifications at a second dam, plans to install them at two more this year, and is studying the possibility of putting them at the TVA's 23 other dams.

These experiences deliver a clear message to the current generation of dam builders: it is possible to minimize the downstream impact of a new dam on the fish, plants, and other wildlife. The government's two dam-building agencies, the Bureau of Reclamation and the Army Corps of Engineers, as well as the Federal Energy Regulatory Commission, which licenses the construction of smaller dams used to produce electricity, have taken note of these environmental concerns. But these agencies expect to build few, if any, new dams on the scale of Glen Canyon in the future. Bureau officials point out that good sites already have dams and those without present other drawbacks. Congress has not authorized any new Bureau of Reclamation dams since 1979, and it has approved only five Corps of Engineers dams in the South and East since 1976. In 1983, the TVA instituted a policy of building no more new dams because of environmental pressures, and also because federal funds for building dams are drying up. Furthermore, some utilities now have surplus power.

Only the Federal Energy Regulatory Commission foresees a growth in dam construction. It licensed more dams for private and public utilities—81 compared with 75—in 1984 than in 1980. These dams primarly generate electricity and at less than 15 megawatts are much, much smaller than any of the dams that the Bureau of Reclamation operates. Yet of 800 hydroelectric dams recently proposed for the four Northwestern states, the National Marine Fisheries Service believes that 100 would be so destructive to fish and wildlife that it is ready to go to court to stop their construction.

Whatever the fate of new dams, those that already exist will keep both engineers and environmentalists busy for the foreseeable future. The question now is not how to tame the rivers but how to keep them wild. □

PHOTOS: RAY TURNER

As the superpowers hedge on arms accords, each grows more suspicious of the other—a trend that could erode existing agreements and prevent significant new ones. This fundamentally political problem requires a political solution.

Arms-Treaty Verification: A Political Problem

In past years, the United States and the Soviet Union have been able to use diplomatic channels to resolve disputes over whether the opposite side is honoring arms-control accords. But now the superpowers regularly accuse each other of cheating on these agreements. The U.S. public is becoming more concerned than ever over nuclear arms-control verification and compliance—over whether Soviet cheating is detectable, and what to do about it.

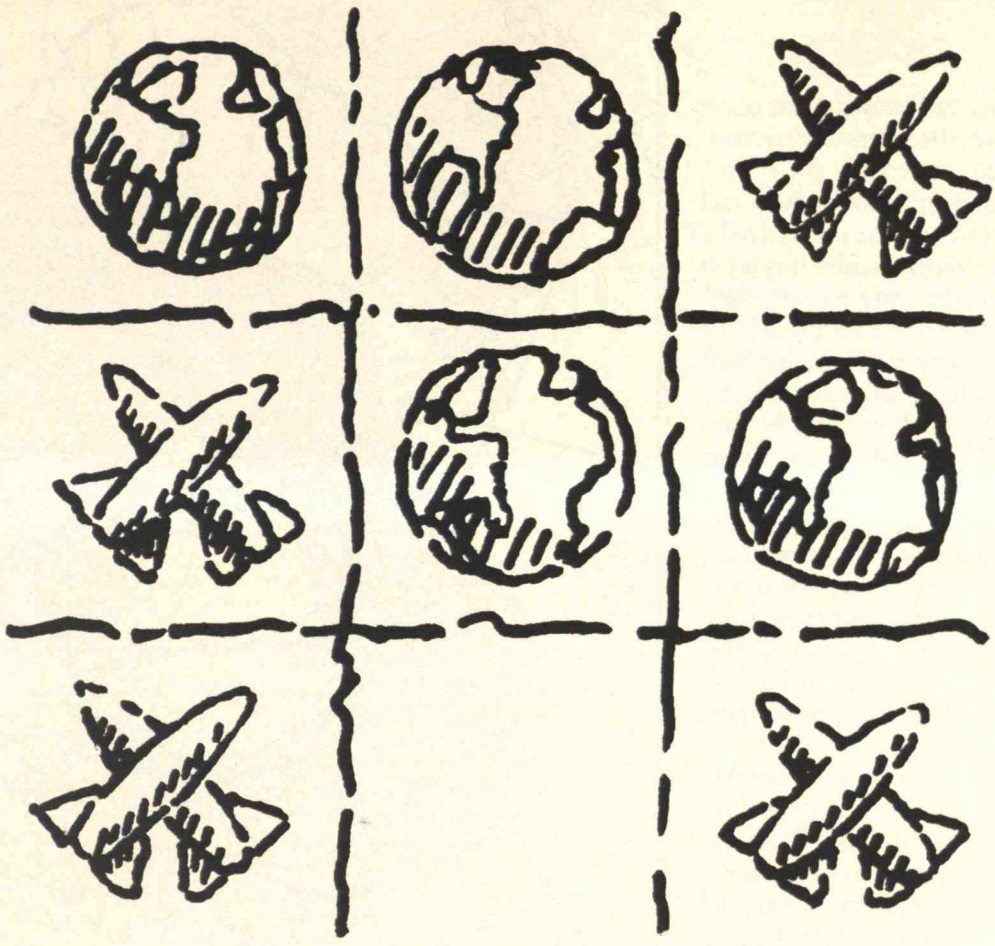
There is no way to ensure near-perfect verification or strict treaty compliance between two powerful nations that can do what they please—at least on their sovereign territory. Each can choose to make verification extremely simple or difficult and each can decide to define treaty obligations strictly or loosely, depending on its own calculations of benefit and risk. These calculations will vary depending on the advice political leaders receive on the military advantages and the political penalties that will result from bending the rules.

During the last five years, the Soviet Union and, to a lesser extent, the United States have acted as if the benefits of interpreting their arms-control obligations loosely have outweighed the risks. For example, the Kremlin is constructing a large "phased-array" radar at Krasnoyarsk in central Siberia. This radar is almost identical to five others located on the periphery of the USSR and "oriented outward" to warn of possible nuclear attacks, as permitted by the 1972 Anti-Ballistic Missile (ABM) Treaty. However, at inland locations, phased-array radars can be heavily defended and are thus potentially useful for ballistic-missile defenses prohibited by the treaty.

Both sides also use these radars for ancillary purposes, such as tracking objects in space. Under the ABM Treaty, radars for space tracking can be located anywhere, and the Soviets contend they will use the Krasnoyarsk radar for that purpose. However, unlike the Krasnoyarsk facility, radars devoted to space tracking are designed to look skyward instead of at the

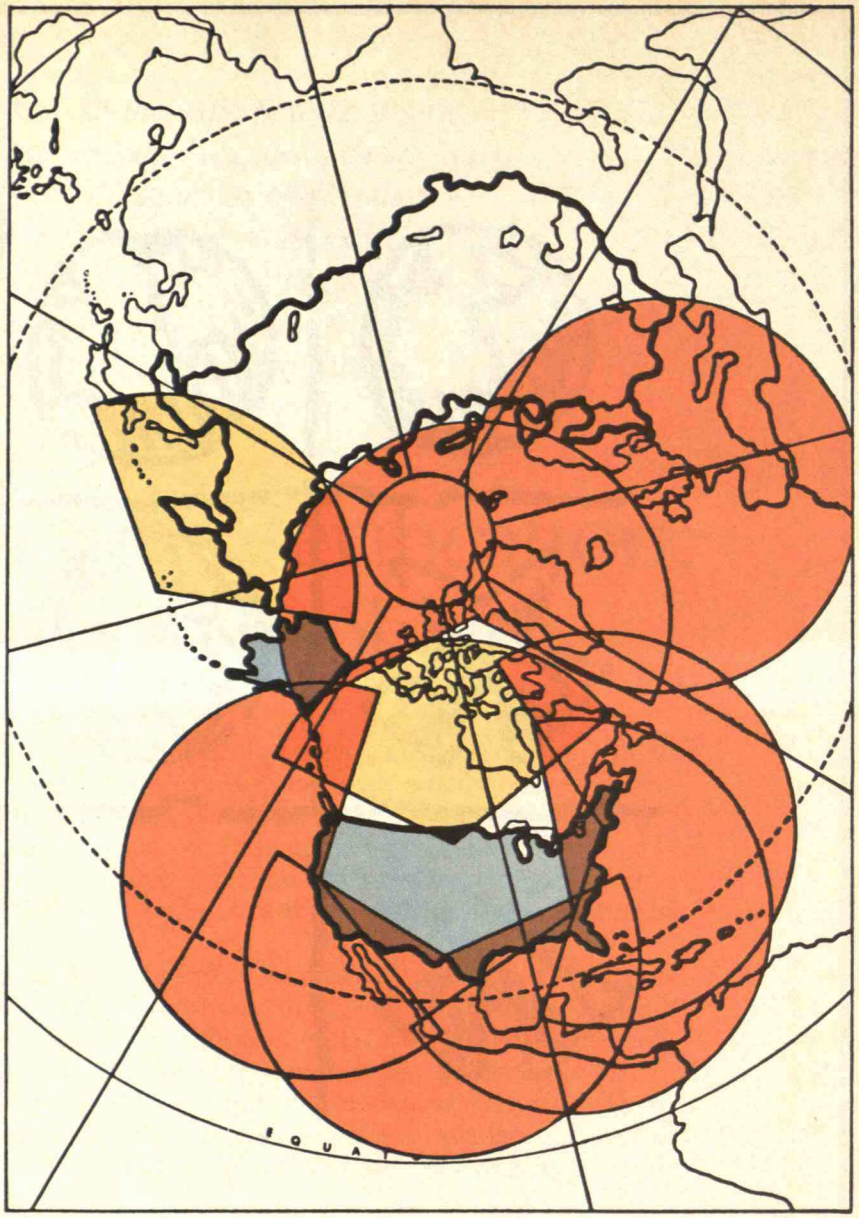
BY MICHAEL KREPON

ILLUSTRATION: JOHN C. YOUNGBERG



YOUR MOVE

One serious dispute over compliance with arms treaties involves powerful "phased-array" radars to track missiles. Right: Projected 1990 coverage of large U.S. radars. Opposite: Projected 1990 Soviet radars. Coverage of disputed radars is colored orange.



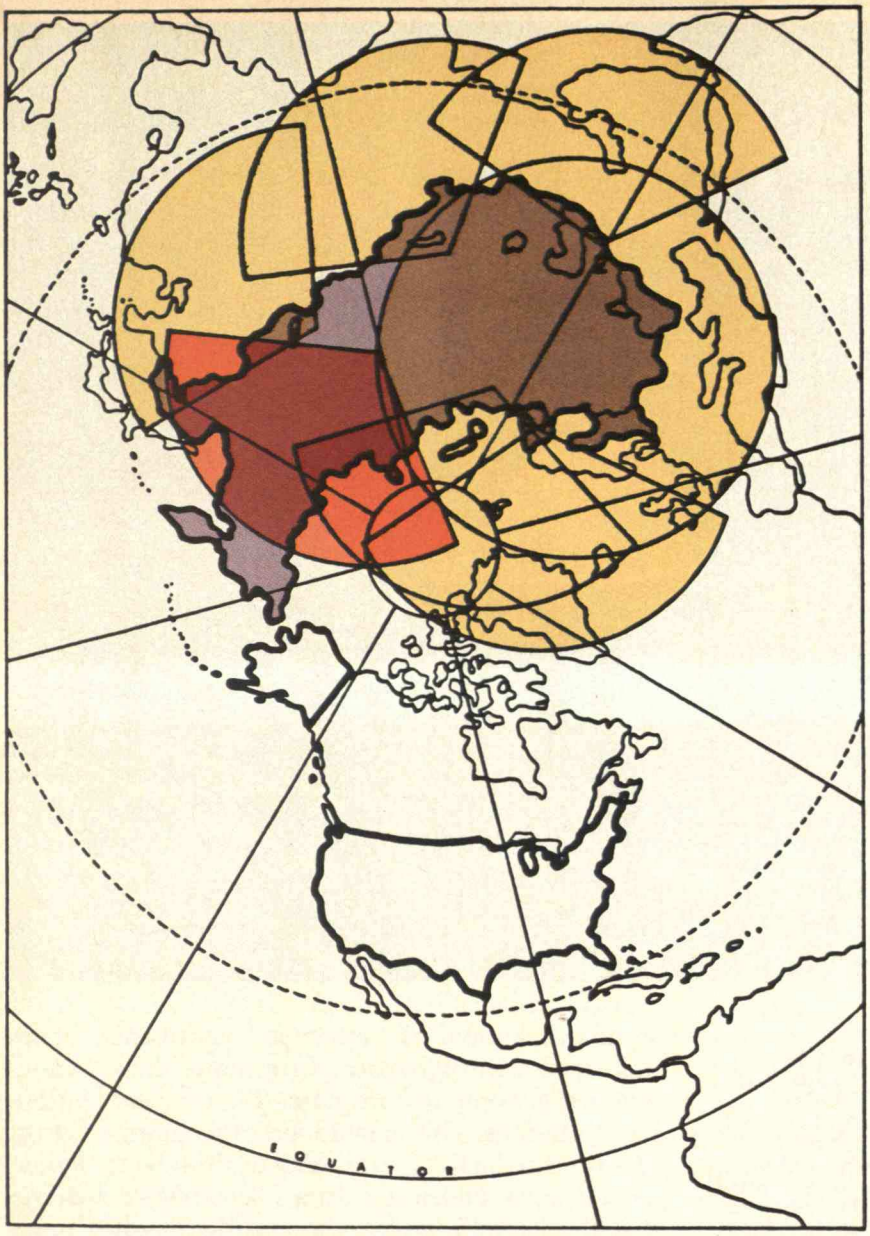
lower elevations of likely attack corridors. Very few observers accept the Soviet argument.

The Kremlin is nibbling away at other provisions of the treaty as well. The Reagan administration has expressed concern that the Soviets are circumventing the prohibition against mobile ABM systems by developing components such as smaller phased-array radars that could be deployed over a period of months rather than years. The USSR is also developing missile-defense systems against short-range ballistic missiles. The treaty permits these modern "anti-tactical" systems, but they may be able to defend against some older intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles as well.

Though of concern, these Soviet developments do not seem to pose an imminent military threat. This is borne out by the fact that the current U.S. defense budget allocates a meager $170 million to improving the capabilities of ballistic missiles to penetrate Soviet defenses. Moreover, while Moscow is hedging its bets against the demise of the ABM Treaty, CIA officials have publicly advised Congress that the Soviets are unlikely to "break out" from the treaty—to suddenly deploy missile-defense systems on a large scale. An effective territorial defense would require thousands of interceptor missiles directed by sophisticated radars and supercomputers able to target incoming warheads in the chaos of nuclear war.

The Kremlin is also concerned about Washington's intentions toward the ABM Treaty. In making the Strategic Defense Initiative (SDI) a national priority, the Reagan administration has created many potential compliance problems. The ABM Treaty prohibits testing ABM-system components such as interceptor missiles and radars—or substitutes based on advanced technologies—except at designated test ranges such as the White Sands Missile Range in New Mexico. Much to the surprise of those who negotiated the original text, administration lawyers reinterpreted the treaty to permit unencumbered testing of advanced SDI technologies. For now, the White House has stated its intention to abide by a "restrictive" interpretation of the treaty provisions, but the groundwork has been laid to adopt the looser interpretation at a convenient time.

Moscow further questions whether new U.S. radar construction complies with the ABM Treaty. New phased-array radars have been built in Massachusetts and California to provide warning of submarine missile attacks. Two more radars are under construction in Texas and Georgia. By the administration's definition, these radars are "oriented outward," as the treaty requires, but they are designed to provide 240-degree coverage, which includes all of the East, West, and Gulf Coasts. In comparison, new Soviet early-warning radars provide 120-degree coverage. The United States is completing a large phased-array radar in Greenland, too, and is about to begin another in the United Kingdom, far from the periphery



of the United States—the citation against Krasnoyarsk. The Kremlin claims that both the radar in Greenland and the one in the United Kingdom represent treaty violations. The Reagan administration asserts that those projects are permitted, since they merely upgrade early-warning radars that pre-dated the treaty.

If the United States and the Soviet Union want to negotiate new arms-control accords—or even maintain existing accords—they will have to resolve verification and compliance problems. Already 1988 presidential hopefuls have begun to offer competing refrains on these issues. Howard Baker, the former Senate majority leader and prospective Republican presidential candidate, staked out his position at an April 1985 symposium at Emory University in Atlanta. Recognizing his audience's conflicting impulses—for arms control but against trusting the Russians—he concluded that on-site inspections are imperative for future arms agreements. Speaking the same month at American University in Washington, D.C., Sen. Gary Hart (D-Colo.) struck a different chord. The man who almost captured his party's 1984 presidential nomination challenged the Soviets to join the United States in a "Manhattan Project for verification . . . to guarantee treaty compliance and prevent nuclear treachery."

These opening volleys of the presidential campaign suggest that skeptics of arms control will strongly advocate inspections. Optimists will emphasize advanced technologies such as sensors on satellites to detect laser tests and seismic arrays to detect very low-yield nuclear tests underground. Each of these approaches can make a substantive contribution and build public support for arms control. However, neither can provide fundamental solutions to problems that are political in nature. A look at the history of the controversies over arms-control verification and compliance will illustrate why this is so.

"Adequate" or "Effective" Verification?

Every domestic nuclear-arms-control debate has featured two opposite political stands on verification. The one prevalent in the Kennedy, Nixon, Ford, and Carter administrations held that concerns over verification should be subordinate to the larger concern of reaching arms-control agreements to improve U.S. security. However, the benefits of any agreement had to be weighed against the risks of undetected Soviet

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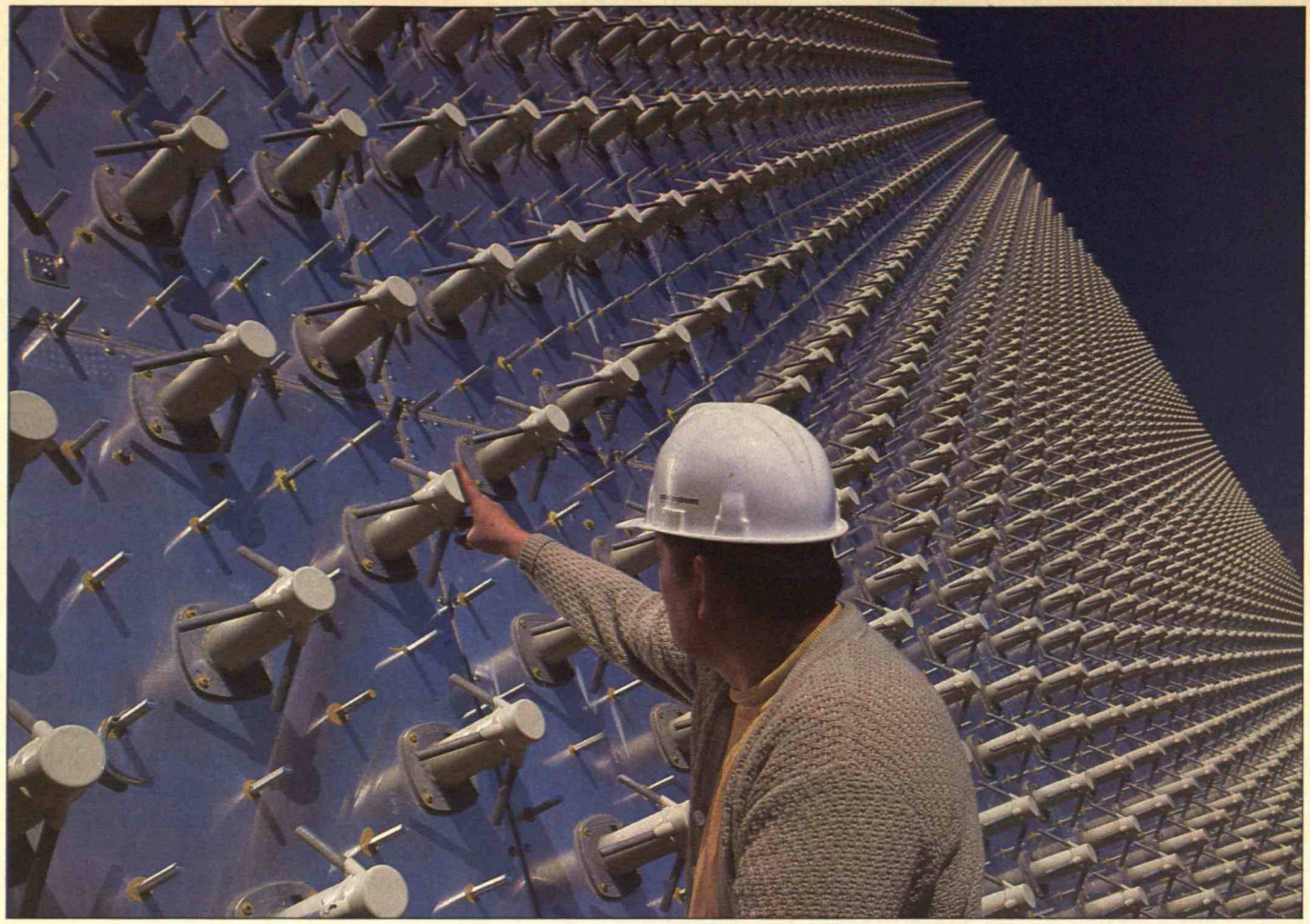
DIAGRAMS: SAVE THE ABM TREATY



A typical large U.S. phased-array radar. The array of small radar antennas is controlled electronically to produce beams that can make a broad sweep in millionths of a second. The phased array can track fast-moving objects such as missile warheads.

cheating. It followed that the United States needed to be able to detect cheating of any consequence in time to take appropriate action. This standard has become known as "adequate" verification.

In debates over the SALT I and II accords, for example, officials of the Nixon and Carter administrations did not contend that they could detect every instance of Soviet cheating, only that they could monitor cheating that mattered. For SALT supporters, the benefits of the agreements outweighed the risks of undetected cheating. And supporters maintained that the United States could respond vigorously if it detected significant cheating. The ultimate retaliation would be to abrogate the agreement in question.

Opponents of past accords reject this calculus of benefits and risks and demand a much more stringent standard, known as "effective" verification. They hold that arms agreements are more likely to constrain U.S. weapons programs than malevolent Soviet ambitions. This view found official favor for the first time in the Reagan administration. For instance, Secretary of Defense Caspar Weinberger believes that the Kremlin pursues a consistent policy of violating treaties, even for small, marginal gains, and when the cheating will be easily detected. Even violations of little military significance are deemed important: if the U.S. response isn't strong enough, the Kremlin will be emboldened to cheat in more consequential areas. In this view, the best checks against nefarious Soviet practices are precisely drafted agreements, including provisions for highly intrusive monitoring techniques, and a policy of tough sanctions in response to violations.

This approach to verification has profound implications for new arms-control agreements, as is becoming apparent in negotiations over intermediate-range nuclear forces (INF). Since INF missiles such as the Soviet SS-20 are mobile, the Reagan administration seeks considerable protection against hidden stockpiles that can be rapidly deployed. So in March 1986 the United States proposed that both sides declare the extent and location of existing missile inventories to be inspected. Other inspection pro-

PHOTOS: RAYTHEON

A Catch-22 blocks any accord on anti-satellite weapons.

cedures would have to be worked out to assure that neither is hiding undeclared stockpiles. However, mobile missiles lend themselves to so many scenarios for cheating that no one is likely to devise a "fail-safe" verification scheme for them. Attempts to do so will instead produce "fail-sure" proposals: schemes requiring such intrusive inspection and monitoring that U.S. officials would probably reject them even if the Kremlin did not.

The implications of the effective verification standard can also be inferred from the Reagan administration's position on ASAT (antisatellite) agreements. Both nations need satellites for many essential functions, including communicating with military forces and warning of nuclear attack. In 1968 the Soviet Union began to test an ASAT launched by a modified SS-9 booster rocket. The Soviet ASAT is cumbersome and has limited striking power and a poor test record, but it easily succeeded in gaining the attention of U.S. officials. The Pentagon responded by developing a faster and far more flexible weapon, an ASAT known as a "miniature homing vehicle" that could be launched from an F-15 fighter.

In August 1983, prior to test firings of the U.S. ASAT, Soviet leader Yuri Andropov announced a unilateral moratorium on further Soviet tests, along with a proposal to eliminate existing ASAT systems and ban new ones. The Reagan administration refused to join in the moratorium or negotiate over ASATs.

A March 1984 administration report defended this position by asserting that a ban posed verification problems. Even if the Kremlin did dismantle its "dedicated" ASATs, it could hide them in storage and quickly deploy them, or attack satellites in other ways, such as by reprogramming its ICBMs to detonate their warheads in space. The Kremlin could also surreptitiously develop new ASAT weapons using ground-based lasers, or use its manned space program to maneuver spacecraft near satellites and disable them. The administration report concluded that Soviet "cheating on ASAT limitations, even on a small scale, could pose a disproportionate risk" to the United States.

Reaching an ASAT accord is therefore blocked by a Catch 22. Critics of arms control contend that partial agreements amenable to verification are not comprehensive enough, while comprehensive agreements are not verifiable.

The Politics of Verification

Demands for highly intrusive verification are not new. In debate over the 1963 Limited Test Ban Treaty forbidding nuclear tests in space, the atmosphere, or underwater, Sen. John Tower (R-Tex.) suggested that ratification of the treaty be contingent upon a reservation requiring systematic on-site inspections. He and other treaty critics pointed out the difficulties of detecting weapon tests in remote ocean areas, next to the Chinese border, in space, behind the moon, under Lake Baikal near Mongolia, or even in the atmosphere under heavy cloud cover. While these worries now appear far-fetched, they seemed more serious then—the United States had not yet orbited satellites to monitor atmospheric testing.

President Kennedy parried these criticisms. After pursuing a comprehensive treaty banning all nuclear tests, he decided to settle on a partial agreement banning them everywhere but underground. This minimized the likelihood of Soviet cheating since clandestine tests in remote areas or in space would be more difficult to carry out than legal tests underground. Gen. Maxwell Taylor, speaking for the joint chiefs of staff, further deflected concerns by arguing that whatever secret progress the Soviets might make would be minor, especially with safeguards such as a strong U.S. underground-test program and improved monitoring capabilities.

In the final analysis, concerns over verification of an atmospheric test-ban agreement and calls for on-site inspections fell on deaf ears: Americans were more concerned about ending radioactive fallout from atmospheric tests. A poll taken shortly before the Senate vote on the Limited Test Ban Treaty showed that four out of five Americans gave it their "unqualified approval." The Senate defeated Tower's amendment for on-site inspections by a vote of 76 to 16 and overwhelmingly ratified the treaty.

Nor did concerns about verification threaten the 1972 SALT I accords, which included an "Interim Agreement" covering ICBM launchers and missile-carrying submarines and the ABM Treaty placing drastic limits on missile-defense systems. Nixon administration officials pointed out that in the text of the SALT accords the Soviet Union had, for the first time, agreed to legitimize "national technical means" of verification—primarily photo-reconnaissance satellites. The Soviets had also agreed not to use "deliberate concealment measures," such as pre-

Iklé was less concerned with monitoring Soviet compliance than with handling violations.

venting the United States from observing the construction of new missile silos or sea trials of new submarines. These provisions seemed more than sufficient for monitoring the quantitative SALT I limits. Secretary of Defense Melvin Laird and Admiral Thomas Moorer, chairman of the joint chiefs, flatly declared that U.S. verification capabilities were equal to the task, and skeptics chose not to dispute their statements.

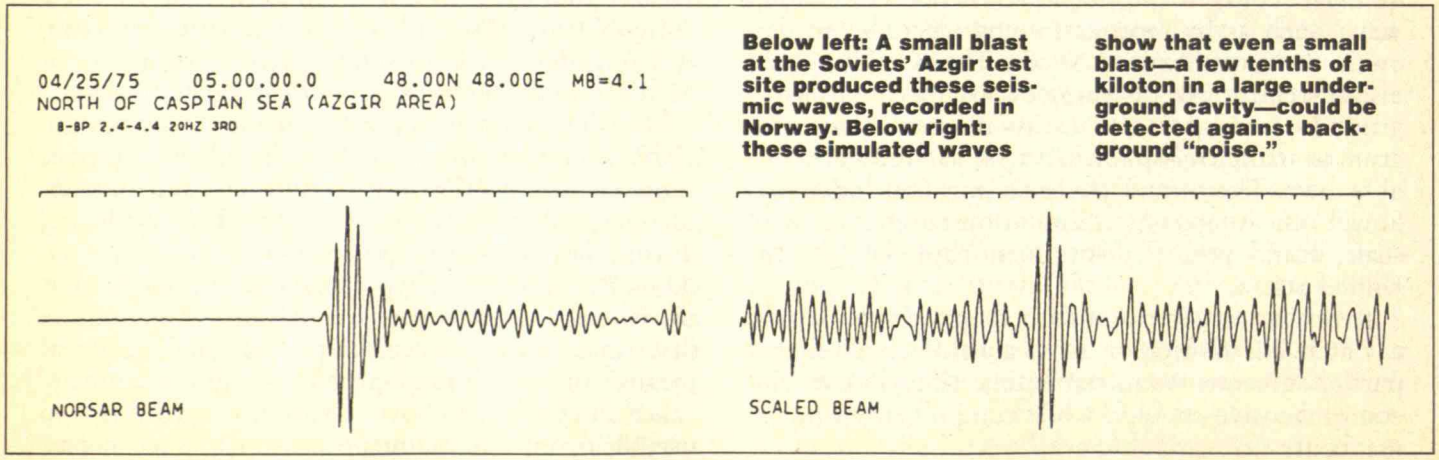
In contrast, critics did effectively challenge the verification provisions of the 1979 SALT II Treaty. Since that treaty required not only counting missile launchers but ascertaining some of their characteristics, it placed extra demands on U.S. monitoring capabilities. Particularly thorny was the provision prohibiting more than one "new type" of ICBM but permitting minor modifications of existing missiles. Characteristics such as missile throw-weight—the weight of the warheads, the guidance device, and aids to penetrate defenses—could be altered by up to 5 percent, but critics doubted whether it would be possible to determine whether this threshold had been crossed. Another troublesome provision permitted some encryption of telemetry (radio signals transmitted from missiles during testing) but prohibited encrypting telemetry whenever doing so would impede verification of treaty provisions. Critics argued that this provision would allow the Kremlin to become the final arbiter of when encryption is permissible.

Carter administration officials provided the same sorts of assurances as their predecessors. They pointed to prospective improvements in U.S. monitoring capabilities and to new treaty provisions to aid verification, such as "counting rules." These rules solved the difficult problem of determining how many warheads are atop silo- or submarine-based missiles by assigning mutually agreed-upon numbers to various kinds of missiles: if, for example, the opposing superpower observed that a missile was flight tested with 1, 6, and 10 warheads, then all missiles of that type were assumed to carry 10 warheads.

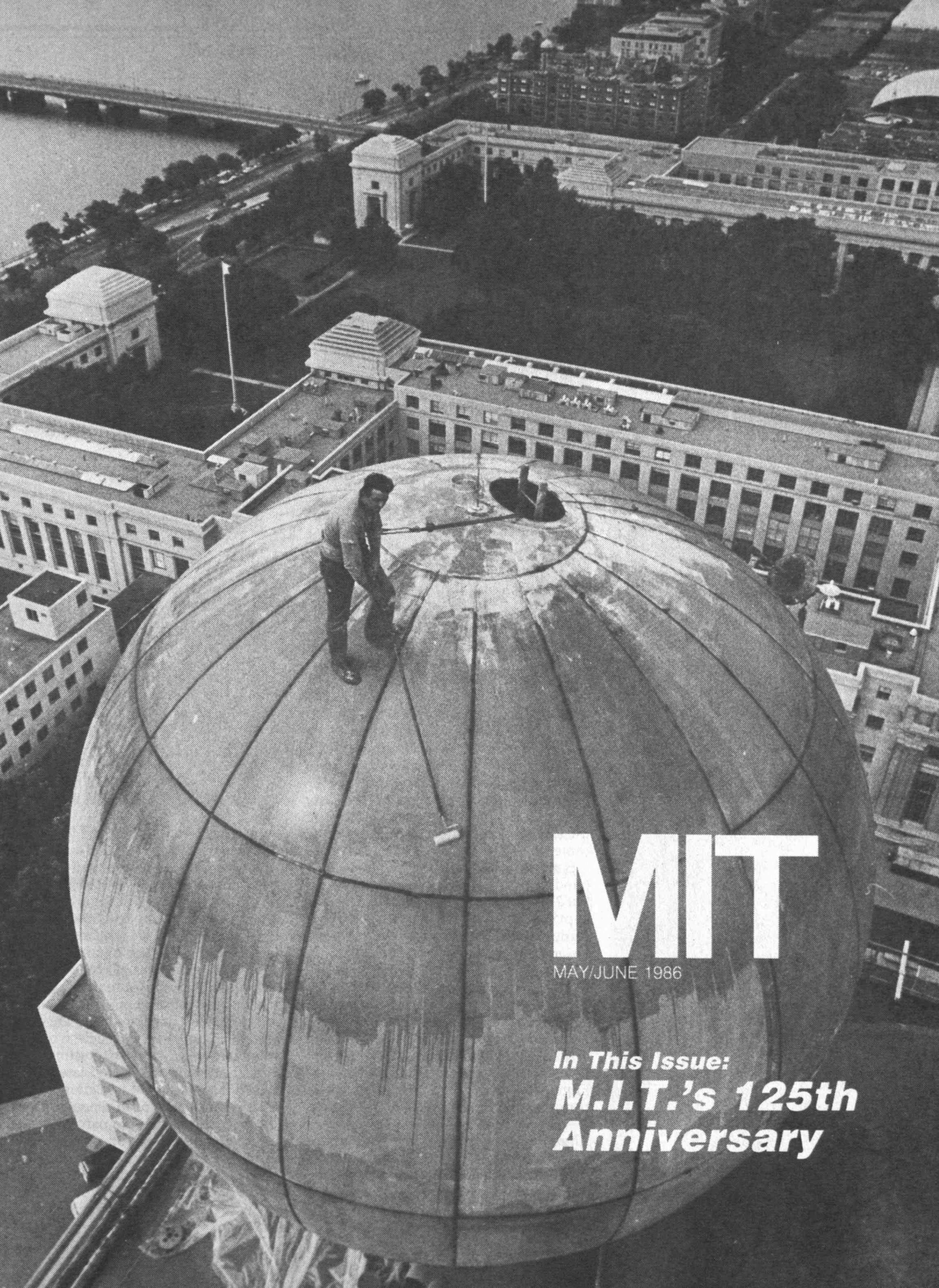
However, those most concerned over SALT II verification, such as Sen. John Glenn (D-Ohio), who cast a symbolically important vote against the treaty in the Senate Foreign Relations Committee, were not swayed by these arguments. Questions about verification became surrogates for broader political concerns, such as President Carter's resolve in dealing with the Soviets. The loss of Iranian monitoring stations with the fall of the Shah and the "discovery" of a Soviet military brigade in Cuba drew public attention to verification issues. The perceived benefits of the SALT II Treaty did not outweigh public concerns over the Kremlin's geopolitical adventures. After the Soviets invaded Afghanistan, President Carter placed the ratification effort on hold. Leaders in both nations subsequently have pledged not to undercut the terms of SALT II, which remains tenuously in effect, though unratified.

The Politics of Compliance

In January 1961, Fred Iklé, then a defense analyst with the RAND Corp. and now undersecretary of defense, wrote an article entitled "After Detection—What?" Iklé was less concerned with monitoring Soviet compliance than with handling violations the United States might discover. At least partial answers are now available to Iklé's question: evidence of So-



Below left: A small blast at the Soviets' Azgir test site produced these seismic waves, recorded in Norway. Below right: these simulated waves show that even a small blast—a few tenths of a kiloton in a large underground cavity—could be detected against background "noise."



MIT

MAY/JUNE 1986

In This Issue:

M.I.T.'s 125th Anniversary

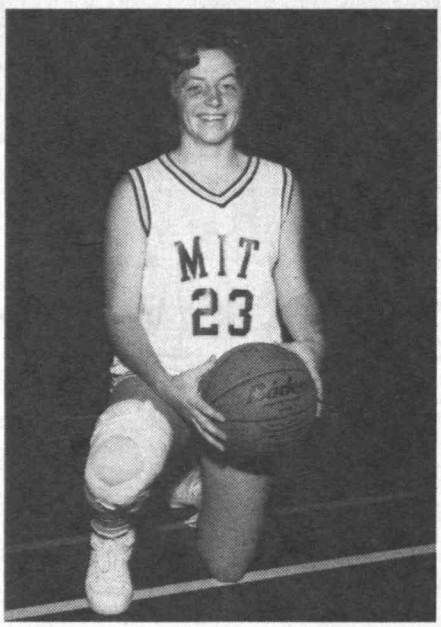
MIT

MAY/JUNE 1986

ABOUT THE COVER

When Calvin Campbell retired after 12 years as the News Office photographer, the M.I.T. Museum mounted an exhibition of his work. Included was this view of the painting of the radome, shot while Campbell perched on the platform for the strobe light atop the 19-story Green Building.

How the Engineers Played Tough at Wellesley



In the end, the coach, still numb, said, "They showed a lot of character."

Smith College defeated the M.I.T. women's basketball team in the first round of the New England Women's Six Championship, but not before the Engineers put their hearts and sneakers to the floor in an emotional comeback that came up just short.

Smith's fluorescent-yellow uniforms blinded M.I.T.'s shot-takers, who sank but 22 percent of their attempts. The exception was "Amazing" Grace Saccardo, '86, who, with a hot hand, scored a season-high 20 points.

Saccardo: she is like a coach on the floor, a clutch player, one who can play back, in her mind, the intricate details of a game.

Coach Jean Heiney: "The ball just wouldn't go in."

M.I.T.'s frustration was epitomized two minutes before halftime when the Engineers put it up four times, each attempt stalled when the ball just wouldn't fall. On the fifth and final try, Judy Mourant, '87, was fouled and went to the line. She made one of two, and the halftime score was 14-11, Smith.

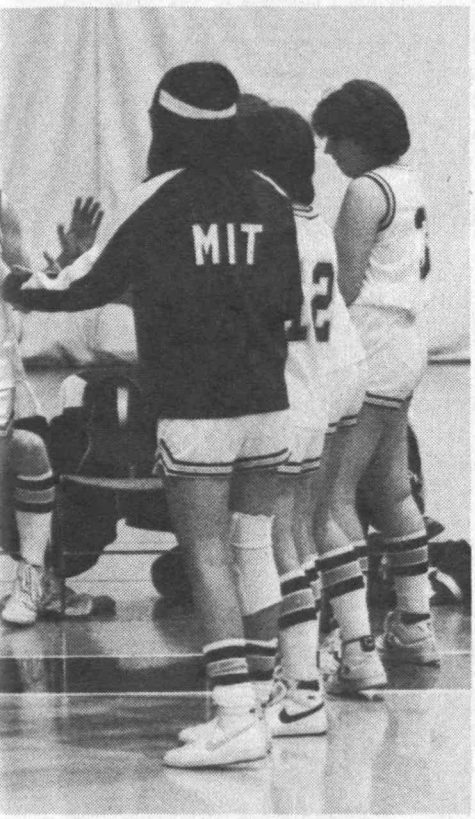
Even as the second half began, nothing seemed to go Tech's way, and the scoreboard finally gleamed: 33-18, Smith. Worried looks decorated the M.I.T. bleachers. The players on the bench were a picture in tension, at the edges of their seats.

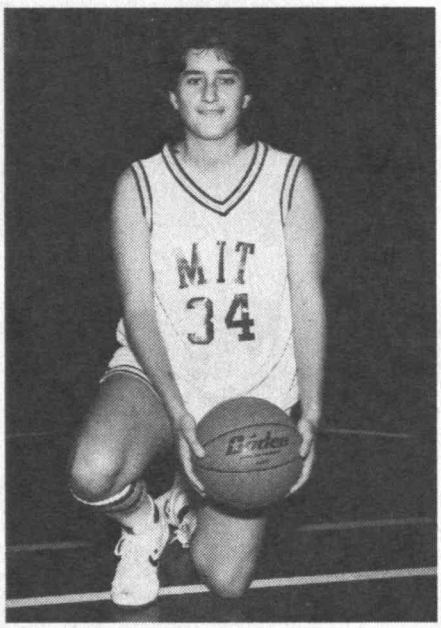
Nobody could have predicted the sensational comeback the Tech women were about to engineer. Unfortunately, it wasn't enough. It was too late. "We almost did it," Saccardo said afterwards.

There comes a point in a post-season basketball game when the players cease to think about their shooting, dribbling or the opponents' defense. They see the scoreboard, with numbers that suddenly make no sense. They hear the timeclock, ticking away, or their hearts,

Alison C. Morgan, '89, describes in The Tech *the climax of the 1986 varsity season for women's basketball at the first New England Women's Six Championship at Wellesley last March.*

PHOTOS: JET COMMERCIAL PHOTOGRAPHERS, KEN CERINO





Left, facing page: Martha Beverage, '87, member of the national Academic All-Star women's basketball team. Above, right: Grace Saccardo, '86, M.I.T.'s 1986 MVP for women's basketball.

beating. And they feel the desire to win transcend the exhaustion of the game. The Engineers reached this plateau with less than eight minutes to go, Smith leading 33-20.

M.I.T.'s Martha Beverage, '87, sank one from the side. Smith turned it over, and Engineer Darlene Dewilde, '88, used the backboard to narrow the difference to seven, 33-24.

Saccardo took control for two straight hoops, and M.I.T. moved closer, 33-28. M.I.T. was fouled on a missed shot with less than two minutes remaining. The Engineers made one of two, but Dewilde took the rebound and made the shot.

Two points separated the teams, and thirty-seven seconds remained in the game. Smith was fouled while bringing the ball upcourt and had to inbounds again. On the inbounds play, M.I.T. stole the ball. But M.I.T. missed the shot, and even though Biz Williamson, '86, got a hand on the rebound, she knocked the ball out of bounds.

Williamson: a vertical take-off or landing aircraft in human form, she combs the boards, and her intensity is just as great in practice as in the game.

It ended when Smith broke through the defense for an easy lay-up and was fouled to seal the victory, 36-33.

But amid all the blues notes, a major chord: the Engineers played tough—they were a part of the first New England Women's Six Championship tournament. "The league is very competitive and anyone can beat anyone else," said Helena Cragg, '87.

Julie Chen, '86: wishing to experience the competitive atmosphere of collegiate sports, she went out for basketball for the first time this year. She was one of the four seniors—Saccardo, Thompson, Williamson were the others—riding the team bus home for the last time. □

A New Head Coach for Men's Basketball

"At some point I knew I had to hang up the sneakers," recalls Leo Osgood, assistant dean for student affairs, explaining his 1970 transition from Northeastern University basketball star to director of social services for Boston's Suffolk County Jail.

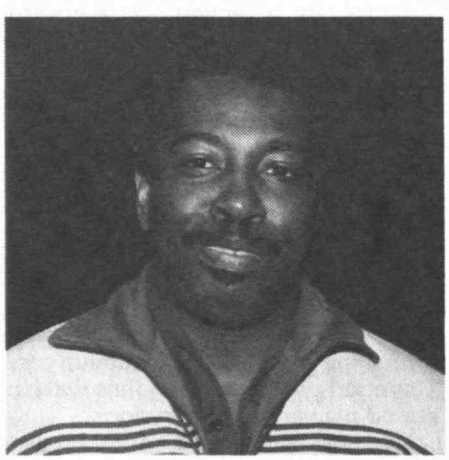
But the sneakers won't stay off.

By 1978, when he was probation officer for the Boston Municipal Court, Osgood became assistant to M.I.T.'s head basketball coach Fran O'Brien. Five years later, on finishing his master's degree in education at Northeastern, Osgood joined the M.I.T. dean's office. Now the transition is complete: beginning next fall, Osgood will be full-time head men's basketball coach at M.I.T.

After 14 years in that job, Osgood's mentor Fran O'Brien is now assistant director of athletics while continuing as head baseball coach and associate professor of physical education.

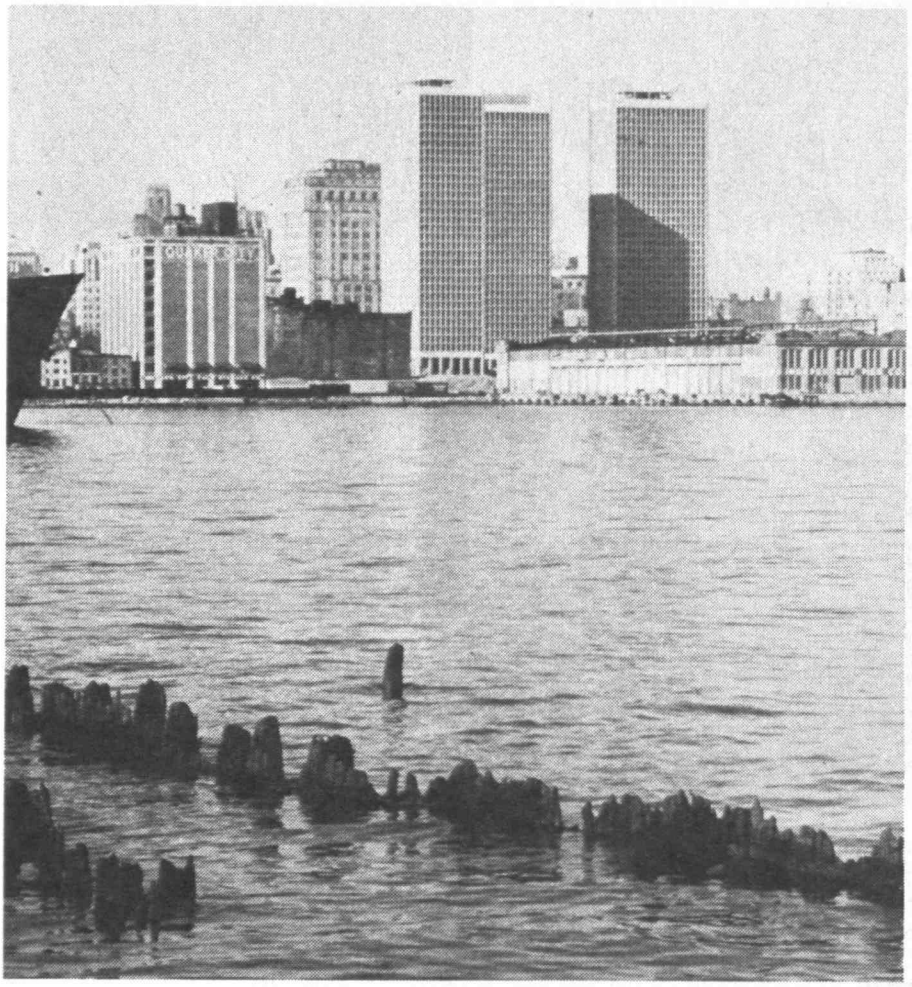
The two colleagues in basketball coaching have only good things to say about one another. "Fran is a wonderful man and excellent mentor," Osgood told *The Tech*. "Leo relates so well," said O'Brien, "to faculty, administration, and students."

Osgood is a long-time basketball official for the Boston high school and community youth programs. He is the first president of Northeastern's Black Alumni Association and a member of the NU Executive Committee. □



Four Themes in the Work of I.M. Pei

M.I.T.'s latest commission of architect I.M. Pei, '40, is the Arts and Media Technology (AMT) Building, dedicated in the fall, 1985, in honor of Jerome and Laya Wiesner. An earlier ceremony honored Albert and Vera List for their role in creating the Visual Arts Center within the Wiesner Building. It was on that occasion that Mr. Pei returned to his alma mater to give an informal, lively and wholly charming description of some of his ideas and work. Highlights from this description follow.



I recall my undergraduate education at M.I.T. as a very indifferent one. We were not inspired; we were groping for a new direction, away from the stylized classical forms that characterized the Beaux Arts tradition. It was fully 20 years after modern architecture had become established in Europe; but only while I was an undergraduate did America begin to sense the need for change.

As far as I was concerned, the new direction was made evident in 1936 by Le Corbusier, who came to spend two days at M.I.T. Those were perhaps the two most important days in my professional life. He was insolent and abusive, but what he said was right on the mark. My final commitment came six years later when I decided to go to Harvard to do post-graduate work under Walter Gropius.

I entered practice in 1949, when there was very little architecture to do in America. An exception was a government program called Title I—The National Housing Act. As a result I was involved for 10 years in that effort to design low-cost housing at $7 to $8 per square foot.

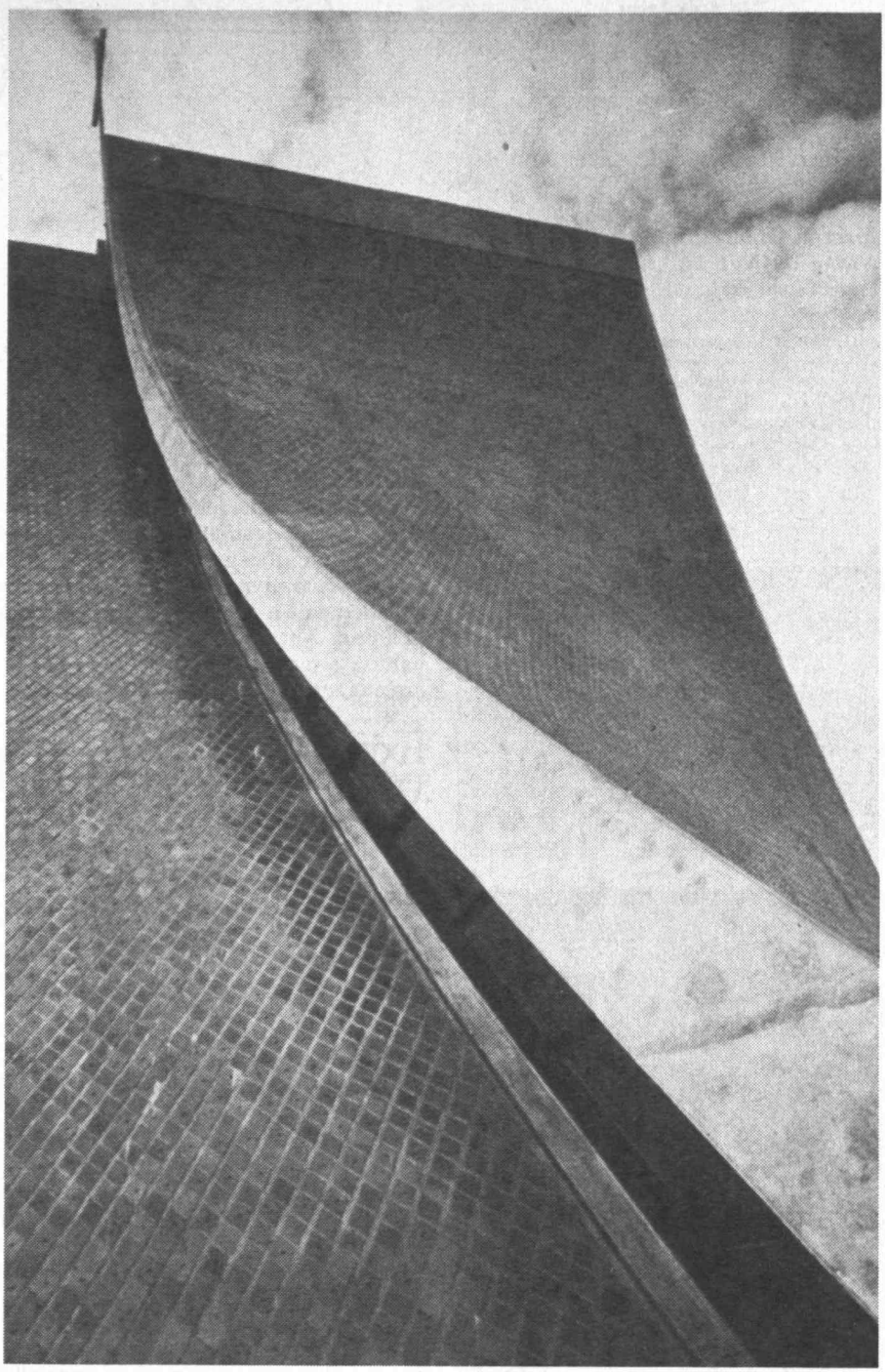
I consider this the first of four thrusts that are central to my work, and though there were more exciting things to come—I often wonder if this first period of my work isn't as important as any of those that followed. The overriding purpose here was to use technology to get something good done at minimum cost. This effort provided a discipline that has served me very well ever since.

However, even in the early 1950s we felt that technology should not be considered in such a limited way, that it could also be used to achieve aesthetic expression. This marks the second thrust of my professional work—that is, to use technology to advance the art of architecture.

Some of the best work by Mies van der Rohe is based on an orthogonal grid system. In the Barcelona Pavilion and many other works, he achieved great richness between parallel planes. However, this work lacks a third dimension, with the result that one rarely experiences spatial complexity in Mies' buildings. This realization led me to what I characterize as a third thrust: i.e., the search for an interplay of spaces and volumes. We all recognize that buildings are solids in space. But we often fail to realize that the spaces between buildings are sometimes more important than the solids themselves. In fact, one cannot avoid thinking in terms of the empty spaces between volumes if one wants to create exciting architecture.

Finally, I would like to say something about the importance of history and tradition. This may be an overused cliche nowadays, but it has been overlooked by architects of my generation. I think an understanding of historical antecedents is absolutely essential if architecture is to be enriched and relevant in a pluralistic world.

PHOTO: GEORGE CSERNA



Facing page: The Kips Bay Plaza apartment project in New York was a 1962 monument to economical design. Left: The Luce Chapel at Tunghai University, Taiwan, used inexpensive local labor to implement a high-tech, wind-resistant design.

Technology in the Service of Economy

Kips Bay Plaza, New York, was started by Robert Moses and completed by Webb and Knapp, with whom I was then working, in the course of five years. This project was contemporary with the Promenade Apartments by Mies van der Rohe in New Jersey, which followed the same architect's Promenade Apartments along the lake front of Chicago. These were very important projects; they started all of us thinking about the possibility of doing architecture with very simple means. We were forced by necessity of economy to take the Kips Bay project one step further than the Promenade Apartments. The latter were built with columns inside and a curtain wall outside; the structure and skin were separate. At Kips Bay we combined the two into one, with the structure becoming the skin. As a consequence of that one change we were able to build this project for $10.15 per square foot. We extended this concept in Philadelphia, where for Society Hill we used standardized two-story concrete forms and jacked them up every two floors. The cost of construction was almost as low as Kips Bay.

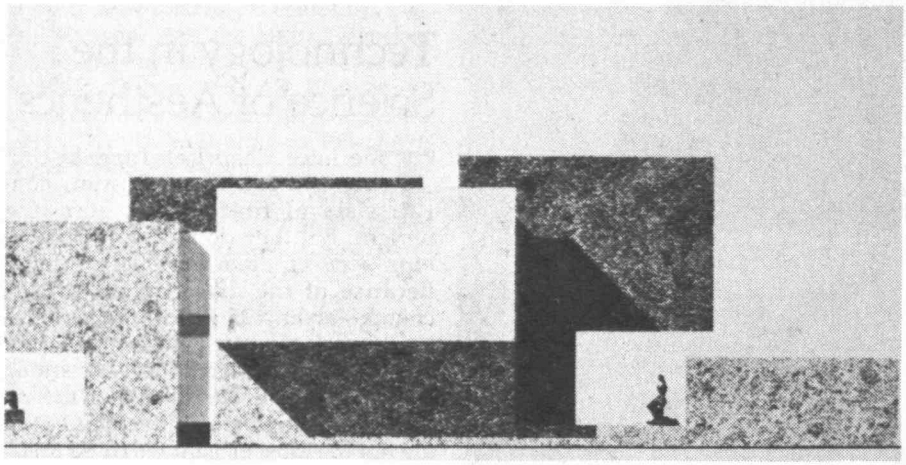
Technology in the Science of Aesthetics

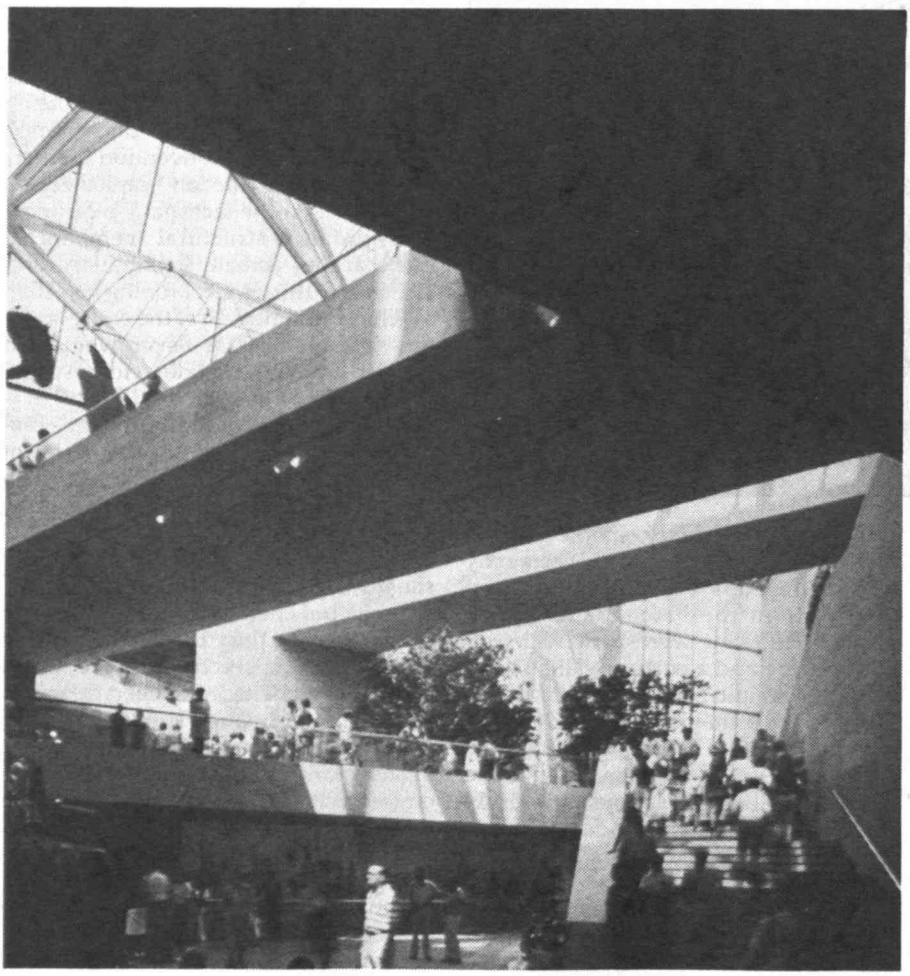
The Luce Chapel at Tunghai University, Taichung, Taiwan, consists of four panels standing upright. But they do not meet, so they form between them interstices of light. Because of the great height of this church—about 125 feet in the center—these surfaces must be warped (not straight) to withstand the very strong typhoon winds. The details of the interstices through which the light enters are not the most elegant we could imagine, but they are the best that could be done in Taiwan in the late 1950s. On the other hand, the inside, also technologically quite interesting, is a lamella construction that could only be done by the abundance of low-cost carpenters.

The New York Convention Center, still under construction, capitalizes to the utmost on the fact that we can now mass-produce structural members so fine that they actually look transparent. The frame utilizes steel tubing less than 3 inches in diameter, yet the entire structure spans 90 by 90 feet everywhere and goes up and down inside to form spatial volumes that are quite exciting.

Another example of technology serving aesthetics is the 72-story Bank of China Building in Hong Kong, probably the ultimate in high-rise construction in a place where high winds govern the design. The plan of this building is a square divided by four triangles that serve as bunched tubes that go up, the second higher than the first, the third higher than the second, and the fourth highest of all. These bunched tubes are cross-braced in six ways, not only in the four surface planes but also in the diagonal planes. As a consequence of this cross-bracing, the loading of the structure progressively goes to the four corner columns. The result is that, at its base, this building is resting on only four columns. This structural plan reduces the steel required to 60 percent of that needed for a conventional structure of

Immediately below: The Everson Museum of Art in Syracuse, N.Y., is a 1968 example of designing with volumes of space in mind. Bottom: The triangular grid of the National Gallery in Washington was dictated by the site.





this height to withstand the predicted wind forces. Forcing technology in this way makes for good engineering, but the architect's challenge remains: Does it provide an aesthetic result? I believe this building meets the test; that it will have a visual dynamism that cannot be equalled with a conventionally designed building. The important point here is joining structure and design to create architecture.

Exploration of Volumes and Space

The Everson Museum of Art in Syracuse consists of six volumes completely connected underground but only loosely joined together above the ground by a large glazed atrium. The separation of volumes is almost complete; the building is six solids floating on a base. Because of the space between them, these volumes develop life and excitement that would not be found if all were joined together to form one mass.

The same ideas apply to internal space. If you move down the nave of a great catheral, you see the columns growing bigger and bigger until you reach the transept and then the altar. The result is fantastic because the church aims to impress, and there's no better way to impress someone than by reinforcing the same perspective spacially and visually, over and over again.

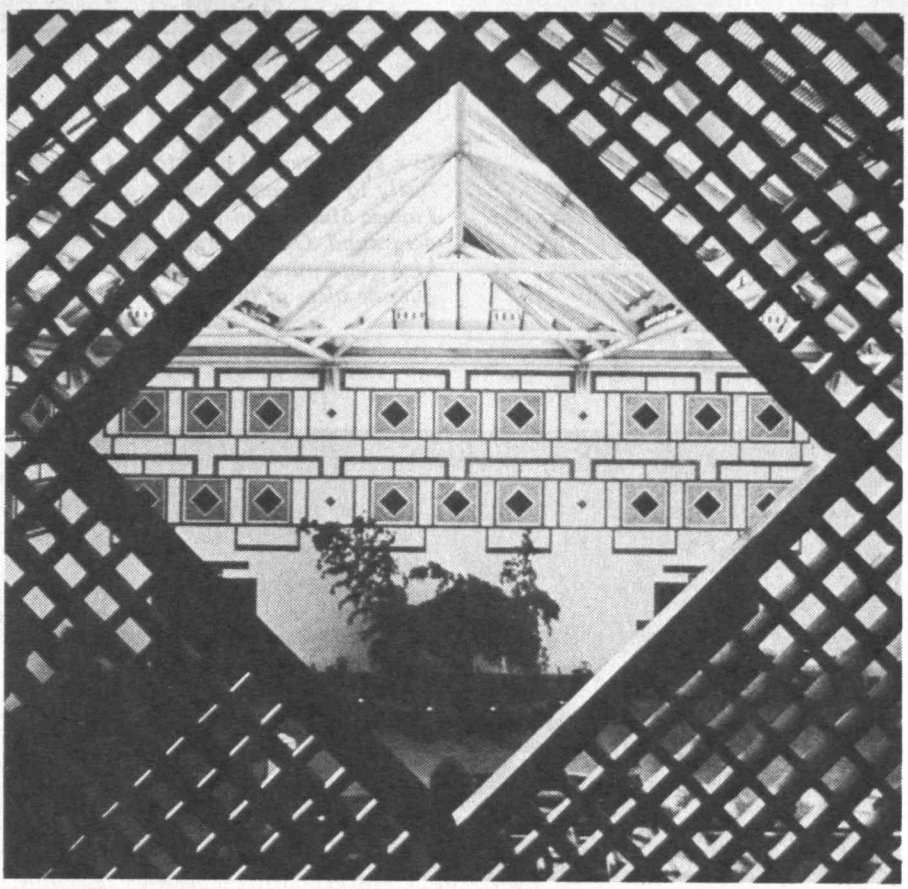
Today our objective in space is very different: we want our space to be alive, to be animated. The triangular grid used in the National Gallery in Washington adds a second vanishing point to the single dominant one of the great cathedral, creating a sense of movement of the planes and volumes. These planes are ordered. The idea of that additional vanishing point had been on my mind for a long time. I had no opportunity to try it because it required a triangular module and I did not want to arbitrarily invoke a triangular grid. But in Washington it was given because the National Gallery site was a triangle.

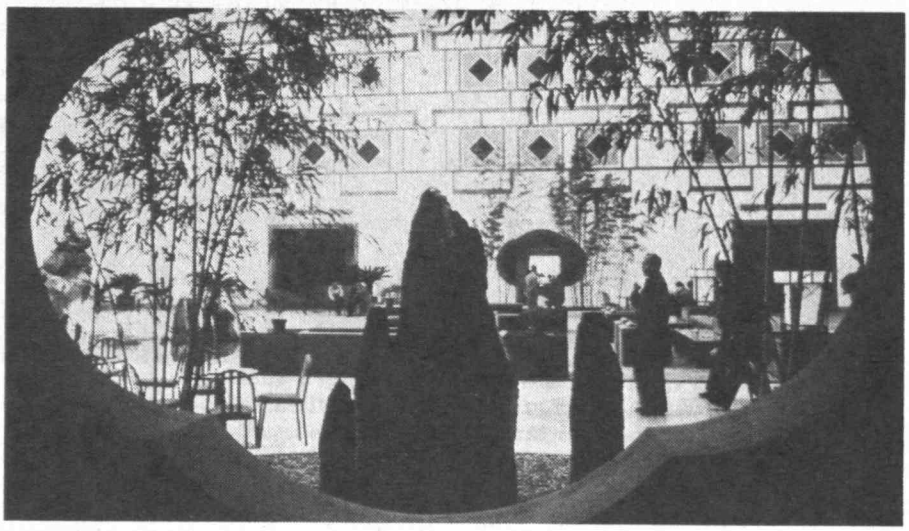
PHOTO: EZRA STOLLER

Returning to Our Roots

At the time I was asked to design the National Center for Atmospheric Research at the foot of the Rocky Mountains near Boulder, Colo., Skidmore, Owings and Merrill had already built the Air Force Academy near Colorado Springs—a series of glass prisms and rectangular volumes reflecting the sky and the mountains. We were tempted by that approach, but we could not take it because the town of Boulder insisted on a building that would not appear to be as large as it was. That challenge turned out to be a blessing, for it led me to discover Mesa Verde, a group of cliff dwellings in caves under an enormous cliff in southwestern Colorado. The buildings look simple—cylinders and cubes, no different from the forms that we use in design. And yet they blend so perfectly with nature that you hardly think of them as made by man. When I tried to analyze why, I discovered the obvious reason: the builders used the same stone that surrounds their structures. But then I discovered another reason, one of scale. The scale of the floor-to-floor systems that we're used to in our office buildings is wrong for buildings in such large environments as the canyons of the southwest or the foothills of the Rocky Mountains. The elemental forms in Mesa Verde are scaleless, so for the first time I committed the sin of not expressing scale in the building for the National Center for Atmospheric Research. The enormous scale of the mountains can coexist with it, and vice versa.

Another example from drawing from richness of history is the Fragrant Hill Hotel, 25 miles outside of Beijing. When I returned to China six years ago I was dismayed and depressed to see rising in Beijing slabs of buildings not unlike those built in Germany after the First World War and in Eastern Europe in the last 10 years, disposed in the city in a checker-board fashion. So when I had an opportunity to do something in China I resolved to find a more appropriate architectural language—one that can still be felt by the people, reflecting elements that are still part of their lives. If such a language could be found, then perhaps Chinese architects, especially the young ones, might renounce the modern international style and seek a new idiom of their own. China is a poor country and its indigenous buildings are of very simple materials. But that does not mean that they have no artistry. The best buildings in China are built of grey tile and tan-colored or white stucco; that combination is everywhere. Because stucco cracks if the areas are too large, patterns of tile are used to break up the surfaces, and this gives the artisans an opportunity to innovate and even to have fun. I also remember from my childhood in China that windows mean something very different than in other parts of the world. In the West, a window is a place to let in light and air—

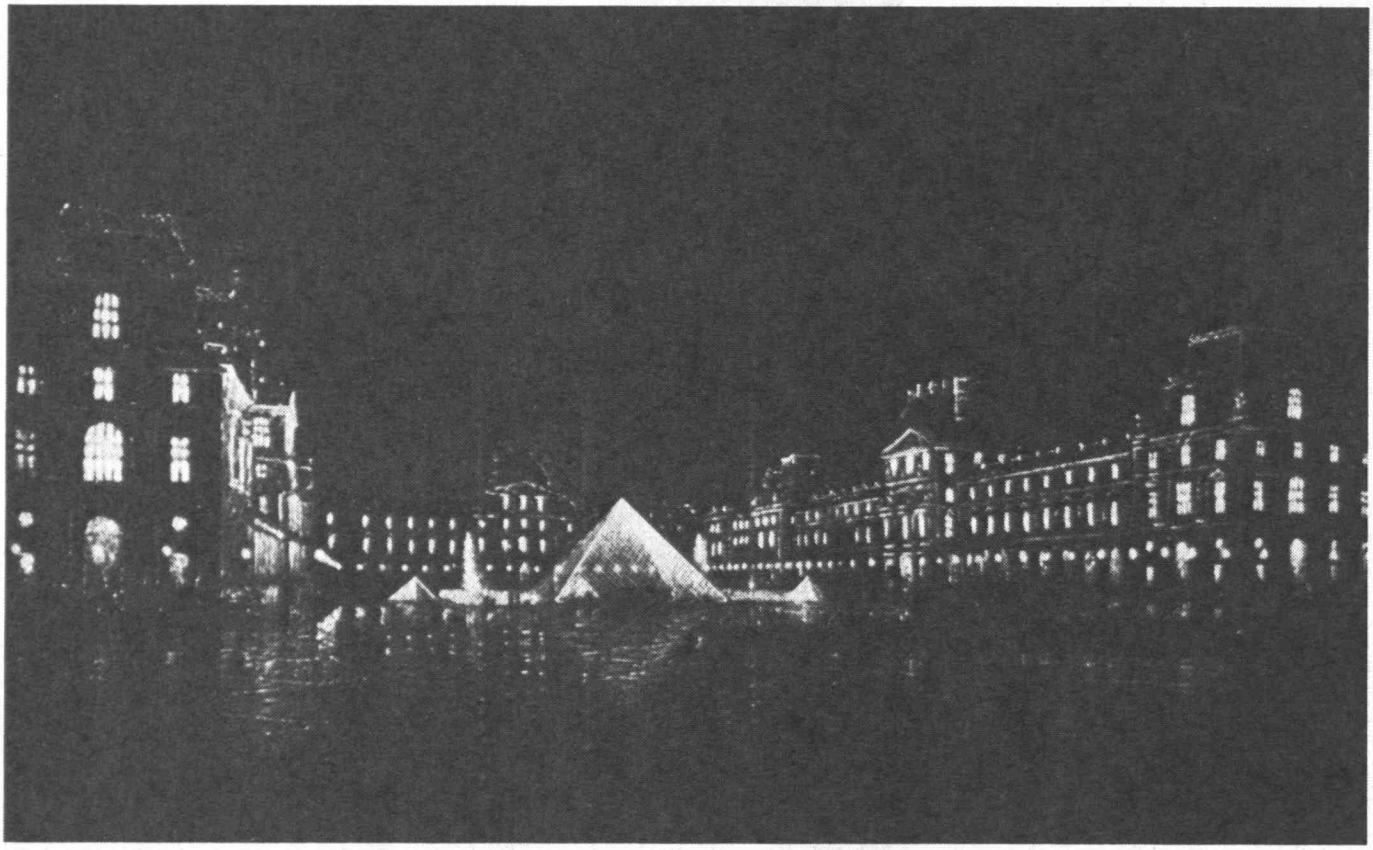




By employing traditional building materials and concepts, such as the idea of a window as a frame for a carefully constructed view, Pei hoped his Fragrant Hill Hotel would inspire Chinese architects to reject modern "slabs of buildings."

PHOTOS: OGAWA, MARC RIBAUD

In a controversial plan to add substantially to the support space of the Louvre Museum in Paris, Pei went underground. Only a dramatic 20-meter-high glass pyramid impinged on the outside view of the French landmark.



largely utilitarian. But in China, a window becomes the frame of a picture revealing a view created by the owners—usually a garden outside. The Chinese frame paintings in many different shapes—circular, triangular, the shapes of vases, fans, even plums. We made generous use of all these traditions in this hotel: courtyard gardens, framed windows, gray tile and stucco panels.

Finally, here is an example of tradition and history arising out of my new work at the Louvre in Paris. I decided to accept the challenge of redesigning the Louvre after four months of study because I came to the conclusion that the Louvre had to change. It has very low attendance; 75 percent of the 2.7 million annual visitors are tourists—typically, French people only go to the Louvre once or twice in their lives, and they hardly benefit from it at all. The average stay of all the visitors—both French and tourists—is less than two hours. President Mitterand himself proposed to make the Louvre for all the people, and particularly the French. The history of the Louvre is almost the history of France, and what a pity, he said, that the French are not enjoying it.

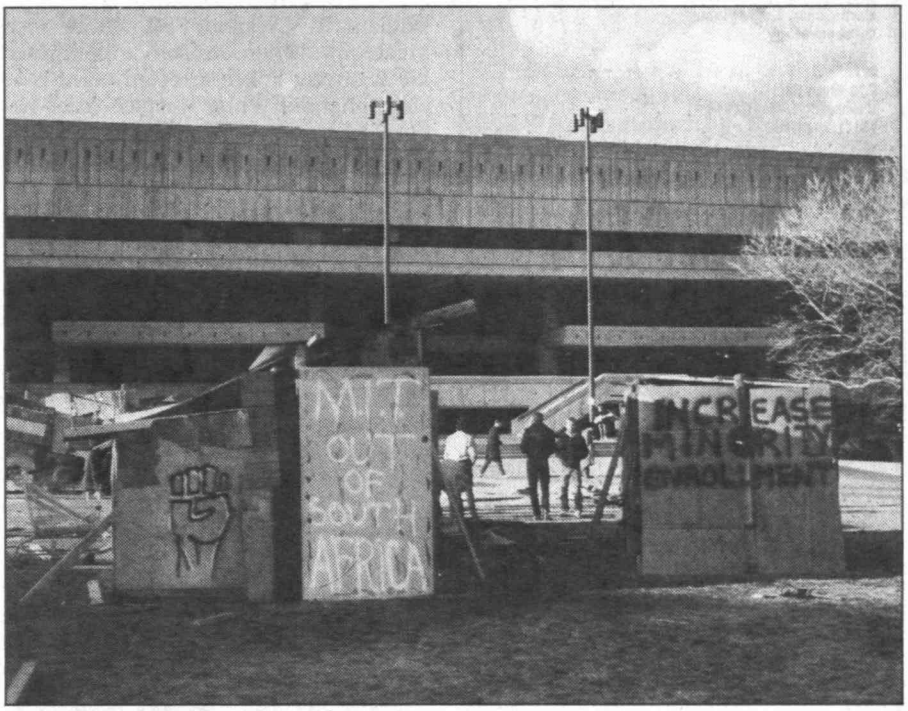
The Louvre has a surfeit of exhibit space. What it lacks is support space—laboratories, a conference center, an auditorium, shops, lots of restaurants. Modern museums in America and Western Europe outside of France use about 50 percent of their space for exhibits and about 50 percent for support; the Louvre is 90 percent exhibit space.

But how can you solve this problem of the Louvre without an addition to it? And if you add to the Louvre, what are you going to do? It seemed to be an almost insoluble problem.

We finally decided on a pyramid of clear glass 20 meters high, 35 meters on each side at the base—a structure of some excitement, surrounded by fountains and by pools. It is in fact a landscape solution, as the glass and water both play with the sky. We do not touch the existing Louvre on the surface; we connect to it underground. On the surface we simply announce that here is the new Louvre; enter. The underground is very extensive—750,000 square feet—with a parking garage and a bus terminal. Tour buses no longer need litter the streets.

The pyramid is all glass; the metal that joins the sheets of glass is only one inch wide. From the inside the pyramid is all stainless steel cables with struts, much like a spider web. It will be a wonderful space full of light, truly the right place to begin a tour of the great Louvre. □

Corporation Approves Limited Divestment While Student Arrests Fuel a New Debate



There was nothing original about the idea of a shantytown to dramatize demands of the student-organized Coalition Against Apartheid. But after 12 days M.I.T. officials concluded the shantytown on the Kresge Auditorium lawn threatened to attract violence. Arrests were made when students tried to prevent M.I.T. workers from removing the shanties, and the faculty voted a motion of "regret" at the administration's action.

M.I.T. has adopted a policy of "selective divestment" in managing its investments in U.S. corporations that do business in South Africa: it will invest only in companies that have signed and "are making progress in the implementation of" the Sullivan Principles. It will divest its stock in any companies "whose conduct is not acceptable according to (these principles)."

That decision was made by the Executive Committee of the M.I.T. Corporation and subsequently endorsed by the entire Corporation early in March. It followed the recommendation of the Corporation's Advisory Committee on Shareholder Responsibility, which said that "companies in which M.I.T. is invested should be actively involved in appropriate efforts to end apartheid."

The Corporation's decision was inconsistent with the non-binding resolution of the faculty of late December (*see February/March, page A8*), and it was vigorously opposed by a student-organized Coalition Against Apartheid. To make its point, the coalition sponsored construction of a small "Alexandra Township" shantytown in the Kresge Oval on March 2. And the views of faculty and administration split again when those shanties were forcibly removed by M.I.T. and several coalition members arrested on March 14.

Supporting a "Positive Force"

In its statement, the Executive Committee said it believed that "the presence in South Africa of those U.S. corporations that are committed to improving the situation for non-whites and that are making demonstrable progress toward that goal is, on balance, a positive force in that nation at this critical time." Its goal, the committee said, continues to be expressing "M.I.T.'s opposition to the repressive and inhumane practice of apartheid, and (encouraging) the movement toward a just policy in South Africa in ways that are appropriate, effective, and consistent with the Institute's nature as an educational institution."

In addition to selective divestment, M.I.T. proposed two other steps to help improve conditions for non-whites in South Africa:

☐ It will award multi-year graduate fellowships—two each year—to black South African students for study at M.I.T.

☐ It will annually fund scholarships that will defray for three years the living expenses of three non-white students at integrated South African universities; the participating universities will absorb tuition costs for these students, bringing the value of each scholarship to about $8,400.

The Executive Committee decision precipitated angry confrontations. There were some tense moments on March 7, when perhaps 50 students gathered outside the President's House and Faculty Club while the Corporation was conducting its regular quarterly meeting. Angry scenes were repeated a week later when M.I.T. employees demolished the shantytown while a few members of the Coalition Against Apartheid tried to stand their ground. The protesters were warned to vacate by

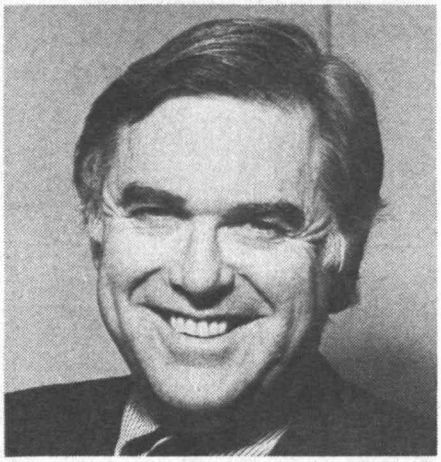
PHOTO: KEN FLOWERS, '86

William R. Dickson, '56, senior vice-president. When resistance continued the Campus Police arrested eight who were charged with "trespass after notice." Dickson explained that the shantytown threatened to become a magnet for violence by opponents of the coalition's stance, that M.I.T. could not continue indefinitely to protect it against such a possibility, and that the lawn area was needed by other activities.

The destruction and arrests proved to be another trigger for controversy. There were questions about the presence of Cambridge police (who were standing by to transport any arrested protesters), about possible overreaction by the administration, and about the adequacy of faculty-adminstration communication in this situation. At a special meeting the faculty approved, 59 to 35, a motion expressing "regret" at the arrests and asking that M.I.T. take "all feasible steps to . . . terminate the prosecution" of those cases and reimburse those arrested for their court costs.

Before the vote President Paul E. Gray, '54 (who was out of the country when the arrests were made), said that he had asked the Institute's attorneys to seek dismissal of the cases of all those arrested, but that he would not reimburse the students' court costs. By ignoring clear warnings, President Gray said, the protesters made a deliberate choice with a predictable consequence, and he did not intend to absolve them of the social and personal responsibility of their decision. (The judge in the case decided not to allow dismissal.)

The immediate outcome of the episode was to sharpen everyone's sense of the need for communication and community. Professors Stephan Chorover and Arthur C. Smith, for example, said they wished the faculty had been more responsive to the developing gap between students and administration on apartheid, and Louis Menand III, former special assistant to the provost who is now senior lecturer in the Department of Political Science, called for more "dialogue on the broad range of issues that face the Institute."—*John Mattill* □



Elkins Is Alumni Director, Secretary

After a year-long search, the Alumni Association has turned to one of its own to be its director of alumni relations and secretary—Webb F. Elkins, S.M.'83.

In his new post, Elkins is in charge of the many programs that support regional activities of M.I.T. alumni, including the five regional directors of the association. He also serves as secretary to the association's Board of Directors and deputy to its executive vice-president, William J. Hecht, '61.

Elkins had some 15 years experience in marketing and business management and planning when he came to M.I.T. in 1982 as a Sloan Fellow; he had been executive vice-president of the Dow Group and group marketing director of Wilson Foods Corp. and of Kimberly Clark Corp. Hecht stressed this experience in his statement welcoming Elkins to the new post, noting the importance of marketing concepts in the association's activities.

Elkins holds two bachelor's degrees—from Holy Cross College (1958) and the American Graduate School of International Management (1960). He had been the Alumni Association's regional director for the midwest and Chesapeake Bay areas since early in 1985. □

Optimizing the Achievements of Technical Women: We Still Have a Long Way to Go

No one doubts that the United States needs to make full use of *all* its technical people in the years ahead. But achieving that goal requires a better understanding by employers and workers alike of the differences in how men and women experience their careers.

That message underlay the sixth annual Conference on Women in Technical Careers, co-sponsored at M.I.T. in March by the Boston section of the Society of Women Engineers and the Association of M.I.T. Alumnae (AMITA).

Conference speakers ranged from a recently retired Air Force general (Wilma Vaught, the only woman to receive the Defense Distinguished Service Medal) to a vice-president of Prudential-Bache Securities (Laura Conigliaro, a financial analyst who specializes in automation, robotics, and machine vision). Their presentations, while diverse, followed common themes:

It is not enough, they said, to give women first-class educations and drop them into responsible slots in first-rate organizations. The women are at risk of early burnout or stalled careers unless they can deviate from the standard male-oriented operating styles of their organizations. But while they push their professions and employers to accommodate their needs, women *can* do more to promote their own careers, the speakers insisted.

Humanizing, Not Feminizing, Science

E. Fox-Keller

Keynote speaker Evelyn Fox Keller reached the issue of difference quickly in her talk on gender in science. She noted that the intuitive methods of cytogeneticist Barbara McClintock were considered somewhat eccentric until McClintock won a Nobel Prize. Only then did her male colleagues hasten to claim her as one of their own.

Keller's point was that there is not any single mode of inquiry practiced by all—that is, the objective mode traditionally associated with men. It is likewise foolhardy to suggest there is a duality—a masculine science and a feminine science. According to Keller, McClintock's approach comes not from a feminist or feminine consciousness but from a determination to claim science as a human rather than a male endeavor. Her career demonstrates the need for scientists to construct their understanding of nature in terms born out of the diverse spectrum of human experience—not out of the narrow spectrum our culture has labeled masculine.

Male Rules for Wall Street

On quite a different tack, financial analyst Conigliaro noted that low-status jobs are usually the door through which women slip into previous male preserves. When she started working on Wall Street, research departments were open to women, particularly in traditionally feminine fields such as household products. But now that male MBAs are flooding into high-paying research jobs, Conigliaro said, the opportunities for women are diminishing. Although Wall Street is performance oriented—your stature is determined by how much money you can earn for your company—women are at a disadvantage because so much depends on informal networks (who you know and what strings you can pull) built up by and for men.

L. Conigliaro

While Fox-Keller is making a strong case for revamping the traditionally male rules for the conduct of science, Conigliaro finds that the male rules for the conduct of business on Wall Street aren't even up for review. Women just have to learn them, she says.

Not Afraid To Be Blunt

Priscilla Marilyn Lu, head of the Microsystems Engineering Department for AT&T Information Systems, on the other hand, doesn't think women should have any trouble playing by male rules. In performance evaluations, for example, women tend to ask, "How can I perform better? Do more?", whereas men tend to say, "I've done this and this, now what are you going to do for my career?" As a manager, Lu recommends a little of both approaches.

Women tend to follow assignments to the letter, said Lu; men tend to expand and re-orient their work, intruding on the territory of others if necessary to enlarge the impact of their jobs. Women, she said, should follow that model. And if they are criticized for going beyond their responsibilities? Ignore it, said Lu. "The manager (who objects to your initiative) is not utilizing your abilities. . . . Don't let criticism for 'being blunt' slow you down. . . . You must get out of the bind of seeking approval; if you aren't stroked, that's the boss's problem." Lu herself has flown in the face of conventional stereotypes about the deference of women and Orientals to authority and has prospered nonetheless.

Getting ahead requires role models, buddies, knowledge of the corporate culture, and real insight into your own strengths and limits, Lu cautioned. If there are no women role models around, she says, adopt the strategies of a man who is doing the job you want to do.

Women must also expect to work longer, harder, and smarter than the men around them, said Brigadier General Vaught. "I don't know anyone successful who doesn't give 12 to 16 hours a day to the job." Vaught also told the conference participants to seek and be comfortable with visibility. If you are in authority, you must "make something happen—see a problem and *do* things about it," urged Vaught, who is credited with dramatically increasing the efficiency of a multimillion-dollar operation while in command of U.S. military entrance processing.

PHOTOS: STUART ROSNER, PRUDENTIAL BACHE SECURITIES

Better Educated, Less Confident

Quite a different perspective on the experience of technically-trained women (and men) is emerging from a study by Lotte Bailyn, professor of organizational psychology and management in the Sloan School of Management, and Dalia Etzion, a professor in the Faculty of Management, Tel Aviv University. At the conference, Bailyn and Etzion described their ongoing research: They mailed two copies of a single questionnaire to a sample of women; the women were asked to fill out one copy and to have one filled out by a male colleague who closely matched their own age, position, and experience.

A preliminary analysis of questionnaires returned by 102 engineers and computer scientists—51 matched pairs comprising close to one-third of the survey group—shows that women in technical professions, in spite of having in most cases superior educational backgrounds and comparable job success and salary, experience lower self-confidence than men.

Bailyn also found that women who place great importance on continued development of technical expertise are particularly prone to low self-confidence, more so than women who have a managerial orientation. Bailyn's research indicates that women in management feel freer than those in laboratories to redefine their work in ways that both men and women who work with them find effective.

L. Bailyn

Women are also subject to higher rates of burnout than their male colleagues, Etzion found. In fact, women who attach great importance to the non-work aspects of life are particularly vulnerable to burnout.

(Burnout is defined as a long-term, increasingly disabling decline in one's sense of well-being and job performance. According to Etzion, it results from a subtle mismatch between a person's interests and abilities and the demands of his or her environment.)

In general, Etzion noted, the very factors that contribute to male success and satisfaction—high level of educational background, challenging responsibilities, and value placed on both work and non-work aspects of life—are indicators of higher burnout for women.

On the other hand, Etzion said, the internalized conflicts that work seems to engender in women begin to level out as they age, so their self-identity solidifies and their job satisfaction climbs. Like men, women lose interest in further developing their technical skills as they grow older. But whereas this leads to a loss of self-confidence for men, Etzion says, it is the reverse for women.

This suggests that the traditional view of a technical career path—early, rapid promotions and then a long plateau—should be revised. The operating style of every organization should allow for the varied patterns of personal development between men and women and among individuals. □

PHOTO: BRADFORD HERZOG

I CIVIL ENGINEERING

Professor **Chiang C. Mei,** whose teaching is in the field of ocean wave dynamics, was honored with membership in the National Academy of Engineering early this spring. Mei's citation was "for application of the theories of wave hydrodynamics and elasticity to problems in coastal and ocean engineering."

John Plaisance, S.M.'85, of Galliano, La., has been working at J. Wayne Plaisance, Inc., since October 1, 1984, becoming vice-president on April 29, 1985. . . . **John P. Wolf,** S.M.'85, is the author of *Dynamic Soil-Structure Interaction,* published by Prentice-Hall (1985). He describes it as "the first textbook in this field." . . . **Jorge Graells,** S.M.'77, is currently director of Institut Cerdá, a non-profit R&D foundation in Barcelona. He wrote that "the firm is beginning cooperative projects with industry and the public sector on digital communications and industrial recycling, to identify strategic priorities for the '90s."

Arthur R. Anderson, Sc.D.'38, and **Gordon R. Robeck,** S.M.'50, were made honorary members of the American Society of Civil Engineers last October 23. Anderson has been involved in the development, design and production of concrete structures for the past 30 years; He was cited for his accomplishments in this field and for "the dissemination of knowledge concerning reinforced and prestressed concrete design." Robeck's career has been with the U.S. Public Health Service and Environmental Protection Agency; ASCE cited him for "major contributions . . . to the development of national, effective, and scientific methods to improving drinking water quality." . . . **Mel Rubin,** S.M.'51, is a reliability engineer at Raytheon Missiles Systems Division, Lowell, Mass.

Captain **Thomas A. Holden, Jr.,** S.M.'84, was decorated with the U.S. Army Achievement Medal at the U.S. Military Academy, West Point, N.Y., where he is an instructor. . . . **Thomas J. Regan, Jr.,** S.M.'68, president of the Regan Co., Washington, D.C., a real estate development firm, is vice-president for construction and a member of the Board of Directors for the Navy Memorial (being constructed on Pennsylvania Ave. by the U.S. Navy Memorial Foundation). Regan was formerly executive director of the Pennsylvania Avenue Development Corp., the government agency overseeing the memorial project.

II MECHANICAL ENGINEERING

William Durfee, Ph.D.'85, **Stephen Kim,** Ph.D.'85, and **Jean-Jacques E. Slotine,** Ph.D.'83, are completing their first year as members of the M.I.T. faculty. Durfee is teaching Introduction to Design and Analysis of Digital Control Systems, and his research is on the electrical stimulation of paralyzed muscles to return function to victims of back injuries. Kim, whose graduate work was in the Laboratory for Manufacturing and Productivity, is teaching courses in manufacturing processes and systems. Slotine's specialty is robotic control, the field in which he worked at AT&T Bell Laboratories before returning to M.I.T. last fall.

Philippe Villers, S.M.'60, made Boston-area headlines twice in one week early this spring: he quit (because of "significant differences in policy") as chairman of Automatix, the company he cofounded in 1980 to make artificial vision systems for robots; and he was the winning plantiff, with Rev. Dana Greeley of the First Parish Church in Concord, of a complaint against the federal government for denying a visa to a Nicaraguan official invited to speak at the church.

Honored for "outstanding, prodigious contributions to heat transfer through analysis and experimentation, and for superlative teaching," **Ephraim M. Sparrow,** S.M.'49, was made a member of the National Academy of Engineering early this spring. Sparrow is professor of mechanical engineering at the University of Minnesota, on leave this year to serve director of NSF's Thermal Systems and Engineering Program in Washington.

Jack B. Chaddock, Sc.D.'55, writes of his most recent activities: "served as general chairman for the Second International Symposium on Moisture and Humidity, Washington, D.C. (April 15-18, 1985); member of Organizing Program Committee for CLIMA 2000, the First World Congress on Heating, Ventilating, and Air Conditioning, Copenhagen, Denmark (August 25-30, 1985); completing 20th (and last) year as chairman of the Department of Mechanical Engineering and Materials Science, Duke University; and plan a sabbatical year at the University of California, Berkeley and Lawrence Berkeley Laboratory in 1986-87."

Richard H. Johnson, S.M.'80, is manager of product and market planning at GMF Robotics, Troy, Mich. . . . **Michael Grant Hollars,** S.M.'80, is completing his Ph.D. in the Aeronautics/Astronautics Department at Stanford University, working on dynamics and control of flexible robotic manipulators under Professor **Robert H. Cannon,** Sc.D.'50. . . . **Lawrence Hofstein,** S.M.'38, writes, "retired from Combustion Engineering; now president of Hofstein Associates, Inc., East Meadow, N.Y., a consulting company; returned to school studying sculpture; and won first prize in student art exhibit for sculpture at Firehouse Gallery in Garden City, N.Y."

Two alumni of the department have been elected to fellow grade in ASME: **Ernest B. Gardow,** S.M.'58, professor and chairman of the Mechanical Engineering Department at the University of Hartford, Conn.; and **Howard C. Merchant,** S.M.'57, founder, president, and principal engineer of Merneco, Inc., Bellevue, Wash., a consulting firm in the field of seismic analysis and nonlinear vibrations. . . . **Thomas L. Geers,** Ph.D.'61, formerly manager of the Applied Mechanics Laboratory at Lockheed Palo Alto Research Laboratory, has joined the University of Colorado as chair and professor of mechanical engineering.

James E. Korenchan, S.M.'84, is currently project design engineer in engine design at the Electro-Motive Division of General Motors. Korenchan is also attending a part-time MBA program at the University of Chicago and lives in Westchester, Ill. . . . **Jesse L. Shearer,** Sc.D.'54, reports that he recently retired to be professor emeritus at Pennsylvania State University but is still active in ASME and as a consultant, writer, and lecturer. . . . **William C. Hall,** S.M.'81, is vice-president in charge of manufacturing at Ramsey Products Corp., Charlotte, N.C. . . . **John T. Katrakis,** S.M.'79, is assistant coordinator of the Energy Research Group at the Center for Neighborhood Technology, Chicago. Katrakis is currently working on a study of energy-conserving improvements for existing single-pipe steam space heating systems in older multi-family buildings. . . . **John C. Chato,** Ph.D.'60, writes, "I finished a one-year term as chair of the Bioengineering Executive Committee at the University of Illinois, Urbana, and I am getting ready to visit the Université Louis Pasteur in Strassbourg, the University of Tubingen in Germany,

Bilding Great Briges

After John H. Slater, '78, assistant professor of civil engineering, gave a talk on bridges to a fourth grade class in Easton, Mass., last winter, the thank-you notes he received put smiles on the faces of all who read them.

Here are some excerpts, just as they were written:

☐ "We enjoyed it very much. I sure hope that you don't hit yourself with a hammer."

☐ "I thought you were very interesting. Some day I think I'll go to your school to learn to make bridges."

☐ "I always wanted to build a brige and now that you told me all about briges I can build one. I hope."

☐ "You explained bridges and how they worked great. You must bild bridges great."

☐ "On February vacation I'm going to maine to see my grandmother and grandfather well what I mean is I have to go over one brige to get to maine and if we want to go food shopping we have to go over another brige that is so tiering but we need stuff well anyway I want to say thanks for coming."

☐ "Now I know more about bridges. I liked when you talked about tension. P.S. does MIT have a football team?" ☐

and the University of New South Wales in Sidney, Australia, as a visiting scholar in 1986."

Charles N. Griffiths, S.M.'37, who ran his family-owned firm, Binghamton (N.Y.) Slag Roofing Co., from 1946 until his retirement in 1984, passed away on November 22, 1985. One year before retiring he was honored with the J.A. Piper Award for distinguished service to the roofing industry. Griffith was active in many community organizations in Binghamton, and he received the 1984 George B. Morgan Award for outstanding service on M.I.T.'s Educational Council. . . . **Bruce A. Martin,** S.M.'81, former project engineer at General Motors' Aerodynamics Laboratory, Warren, Mich., died in a boating accident on June 25, 1985.

The following deaths have been reported to the Alumni Association, with no further information available: **Frederick R. Gruner,** S.M.'41, of Green Valley, Ariz., on October 27, 1985; **Alwin B. Newton,** S.M.'32 of York, Pa., on October 29, 1985; and **William J. Suchors,** S.M.'35, of Jacksonville, Fla., on March 19, 1985.

M. E. Prengaman

J. V. Carisella

III MATERIALS SCIENCE AND ENGINEERING

Professor **Merton C. Flemings,** '51, head of the department at M.I.T., is cochairman (with Praveen Chadhari of IBM) of a study committee to prepare a "status report" on materials science and engineering for the National Research Council. The purpose is to summarize recent progress and outline future research opportunities, and the final report is due at the end of 1987.

Up to $1 million in cash and another $1 million in equipment and software will come from IBM over the next five years for an M.I.T. research program on new materials and processing techniques for advanced computer systems. The research and graduate-level teaching will be in this department, under the direction of Professor Flemings, and in the Program in Polymer Science and Technology headed by Professor Robert E. Cohen (chemical engineering).

Yet-Ming Chiang, Sc.D.'85, has joined the M.I.T. faculty as assistant professor and is teaching the course in glass science and technology this spring while pursuing research on ceramic composites and grain boundary properties. . . . Also finishing his first year on the faculty is **Erik Spjut,** Ph.D.'85, whose teaching is in the field of the physical chemistry of materials; he was a research associate in chemical engineering, the field of his doctorate, last year.

Professor **H. Kent Bowen,** Ph.D.'71, who is director of M.I.T.'s manufacturing and processing systems program was elected to the National Academy of Engineering early this spring, cited for "leadership and innovative developments in advanced ceramics."

Robert A. Wasson, Ph.D.'78, writes that he "joined A.T. Kearney Technology, Inc., Redwood City, Calif. (subsidiary of A.T. Kearney, Inc.), a management and consulting firm specializing in technology management and business strategy. Before joining, I was with the Corporate Research Department of Chevron Research. While at Chevron, I organized the Petroleum Environmental Research Forum, an industrywide R&D consortium devoted to development of new waste treatment technology for the petroleum industry." . . . **J. V. Carisella,** Sc.D.'78, is general manager of the newly-formed Associated Technologies, Inc., New Orleans, a petroleum production materials and quality assurance consulting firm. . . . **George T. Campbell,** Ph.D.'71, has been promoted from technical director to vice-president of research and technology at Shieldalloy Corp., Newfield, N.J., a leading producer of alloys, chrome metal, and metal powders and other speciality products for the metal and glass industries.

Michael E. Prengaman, S.M.'84, assumed the position of manager—forming and heat treating at the Timken Co.'s new Technology Center, Canton, Ohio. He's been associated with Timken's metallurgical programs since graduating from M.I.T. . . . **Donald R. Kotansky,** Sc.D.'66, of Chesterfield, Mo., passed away on January 9, 1986.

IV ARCHITECTURE

At the invitation of Boston Mayor Raymond L. Flynn, Dean **John deMonchaux** of the School of Architecture and Planning is the first chairman of a new Boston Civic Design Review Commission. The 13-member group will make recommendations to the mayor and the Boston Redevelopment Authority on the design of major development projects. BRA director Stephen Coyle says the goal is "to convince architects and developers that Boston is serious about design issues."

The memory of **Robert B. Newman,** M.Arch.'49, will be honored at 15 schools of architecture throughout the U.S. later this month, when Newman Medals are given to students for excellence in the field of architectural acoustics. The program is organized by a committee that includes Professor Emeritus **Lawrence B. Anderson,** '30, and contributions to fund future awards may be sent to Box 349, Lincoln Center, Mass. 01773.

Samuel C.M. Wang, M.Arch.'62, has been appointed a senior vice-president of Cannon Design, Inc., Grand Island, N.Y. Wang, with Cannon since 1975, will lead the company's design review program, which was established to ensure adherence to high-quality design standards. . . . **Earl E. Stewart,** M.Arch.'53, writes: "I am retiring from my position as chair for the Graduate Program in Community and Regional Planning at North Dakota State University to enter planning and architectural practice. Have been a university professor of 33 years since graduating from M.I.T."

V CHEMISTRY

The Chemistry Department has been honored with the first Class of 1943 Career Development Professorship, given early this year to **Sylvia T. Ceyer** who will hold it for three years. Assistant Professor Ceyer, who joined the faculty in 1981, was cited for "recent stunning work on chemisorption of carbon monoxide on nickel surfaces" and for "outstanding contributions to education."

Ronald A. Hites, Ph.D.'68, will give a one-week course in environmental applications of gas chromatographic mass spectrometry at Indiana University starting on July 28. Hites is professor of public and environmental affairs and professor of chemistry at Indiana, but this summer's course was first developed while he was a member of the faculty at M.I.T.

F. Albert Cotton, who was a member of the M.I.T. faculty from 1955 to 1972, was honored early this spring with the Theodore William Richards Medal of the Northeastern Section of the American Chemical Society. The medal rewards "conspicuous achievement in chemistry," and Cotton spoke following the presentation on the importance of metal-to-metal bonds. He is the Doherty Welch Distinguished Professor and director of the Laboratory for Molecular Structure and Bonding at Texas A & M.

Membership in the National Academy of Engineering came early this spring to **John T. Wise,** Ph.D.'66, manager of Mobil Research and Development Corp.'s Paulsboro (N.J.) Laboratory. Wise was cited for "inspiring technical contributions and leadership in the development and commercialization of important petroleum, petrochemical, and synthetic fuels processes."

Steven L. Regen, Ph.D.'72, has been appointed professor of chemistry at Lehigh University. Regen was previously a professor at Marquette University. . . . **Ronald Francis,** Ph.D.'64, has been named the first Frederick and Anna B. Wiedman Professor in Imaging Science at Rochester Institute of Technology. Francis is associated with RIT's newly created Center for Imaging Science before joining RIT in 1969 worked at EG&G, Itek, and Arthur D. Little, Inc. . . . **Homer Fay,** Ph.D.'53, retired from Union Carbide on December 31, 1985. . . . **Alexander Mac Lachlan,** Ph.D.'57, former director of the Central Research and Development Department at the Du Pont Co., Wilmington, Del., has been appointed senior vice-president—technology, responsible for the Engineering, Information Systems and Central Research and Development Departments. Mac Lachlan joined Du Pont in 1957 as a research physicist in the Engineering Department and through the years was given progressively more responsible positions in research.

Joda C. Wormhoudt, Ph.D.'76, has been promoted from principal research scientist at Aerodyne Research, Inc., Billerica, Mass., to director of the Center for Chemical and Environmental Physics. . . . **Roscoe "Ros" Pike,** Ph.D.'53, was among 14 United Technologies Research Center scientists, engineers, and support personnel cited for extraordinary achievements and contributions during 1985. Pike, manager (polymer science) in the Materials Technology Department, was cited for his development of a completely new inorganic adhesive joint primer which improves bonded joint performance and reliability.

Claus A. Wulff, Ph.D.'62, professor of chemistry at the University of Vermont since 1965, passed away on September 18, 1985. He was a member of the American Chemical Society and Sigma Xi.

VI ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

After a career in NASA, Satellite Business Systems, and DARPA, **Robert S. Cooper,** Sc.D.'63, has formed a consulting and research company called Pollard Road, Inc., Crystal City, Arlington, Va., to do signal processing for the Defense Department and intelligence services. Before leaving DARPA, he had been studying applications of ramjet engines to hypersonic flight, including the "Orient express/space plane" proposal that President Reagan embraced early this year.

John E. Savage, '61, is co-author (with Susan Magidson and Alex M. Stein) of *The Mystical Machine: Issues in Computing* (Addison-Wesley, 1986). It's a college-level textbook on the computer—how it works, what it does, and—especially—its potential benefits and dangers. Savage is chairman of the Brown University Computer Science Department, and his co-authors are students in the department.

John N. Tsitsiklis, Ph.D.'84, joined the M.I.T. faculty last fall to teach the courses in Parallel and Distributed Algorithms and to continue his research in that field and in optimization theory.

Roger Putnam, Ph.D.'83, has been appointed co-director of the Center for Optical Sciences at Aerodyne Research, Inc., Billerica, Mass. Putnam joined Aerodyne in 1984 as senior research scientist. . . . **Robert H. Eisengrein,** S.M.'49, writes from Acton, Mass: "Have been happily retired for three years now. Do my one consulting job per year to keep up with technology and earn some 'pocket money' for special trips." . . . **Ronald W. Schafer,** Ph.D.'68, recently received the Class of 1934 Distinguished Professor Award from the

Georgia Institute of Technology. . . . **Thomas C. Warner, Jr.**, S.M.'47, reports two milestones: "In January 1984 I married Helen J. Hollowell. In May 1984 I retired as professor of mechanical engineering and dean of the School of Engineering at the University of New Haven."

Edgar A. Miller, S.M.'67, reports, "Life going well as a general partner of Concord Partners—a $115 million venture capital fund associated with Dillon, Read and Co." . . . **Edward Bowles,** S.M.'22, and his wife Lois have established an endowment to support the Massachusetts Eye and Ear Infirmary in establishing a new center for opthalmic educational activity. The endowment will finance the construction of a teaching center and will support future education programs. . . . **Timothy R. Hart,** S.M.'60, professor of physics and engineering at Stevens Institute of Technology, Hoboken, N.J., was honored at the institute's convocation ceremony last September 4 with the honorary master of engineering degree, for his "initiative, versatility and breadth of interest . . . a first-class experimental scientist." . . . **Carl D. Cordua,** S.M.'31, of Bronx, N.Y., passed away on May 20, 1985; no further details are available.

VI-A Internship Program

At this writing (March 27), the final phase of the annual VI-A selection process is about to begin. Our participating companies conducted 992 interviews from among the 192 sophomores who applied for admission. 60.2 percent of Course VI sophomores applied this year, a 1.5 percent increase over last year's class. When selections are complete, we estimate there will be around 96 in the new VI-A class—about the same as last year. This spring's VI-A enrollment is 278; the department's target is still 255-260.

'Tis the season for awards and honors, and a number of VI-A'rs have done well. We'll mention them alphabetically:

Richard B. Adler, '43, was awarded this year's Education Medal by the IEEE at its annual meeting in San Jose, Calif., in February. Adler was cited for "leadership in engineering education through teaching and textbooks in semiconductor electronics and electromagnetics." He received a gold medal, a bronze replica, a certificate, and $5,000. Dick is currently serving as Associate Department Head for Electrical Science and Engineering in Course VI and is responsible for the overall co-ordination of the VI-A Internship Program.

Arthur C.M. Chen, '61, has been elected a fellow of the IEEE, cited "for contributions to the application of computer technology in medical electronics and to the automation of electric power distribution systems." He is with General Electric's Corporate Research and Development Laboratory, Schenectady, N.Y., and recently stopped in to see Director Tucker during a visit to M.I.T.

Eta Kappa Nu's Distinguished Service Award has been given to **Anthony F. Gabrielle,** '49, "for his many years of important service." He and Mr. Tucker served on the National Board of Directors together, and Tony became national president of the honor society in 1970-71. Tony is currently vice-president—computer applications with Gulf States Utilities Co., Beaumont, Tex. Prior to this he served with American Electric Power Co., New York City.

A national honor was bestowed on **Bernard M. Gordon,** '48, by President Reagan at a White House ceremony. Gordon was one of six recipients of the National Medal of Technology; he was cited as the "father of high-speed analog-to-digital conversion" and for his successful entrepreneurship and contributions to education. Gordon is president and chairman of the board of Analog Corp., Peabody, Mass.

Bruce D. Wedlock, '56, has been elected a fellow of the IEEE. Bruce was cited for his "contributions and leadership in electrical engineering education." He is currently director of M.I.T.'s Lowell Institute School and was co-author, with Professor **Stephen D. Senturia,** '66, of the popular text *Electronic Circuits and Applications.*

The April meeting of the local Ultrasonics, Ferroelectrics, and Frequency Control Chapter, IEEE, will feature a talk by **Gary K. Montress,** '69, entitled "A High-Performance, Miniature Hybrid-Circuit SAW Oscillator." Gary is currently on the professional staff of Raytheon Co.'s Research Division, Lexington, Mass.

The March 1986 issue of the *Hewlett-Packard Journal* carries an article on "Software Test Automation" of which **Craig D. Fuget,** '83., is co-author. Craig is with Hewlett Packard's Computer Group in California. . . . The current board of *The Tech* is comprised of more VI-A students than I can recall from the past. **Harold A. Stern,** '87, is editor-in-chief; **Eric N. Starkman,** '87, is managing editor; **Thomas T. Huang,** '86, is executive editor; and **Sidhu Banerjee,** '87, and **Andrew S. Gerber,** '87, are contributing editors.

It is always interesting to note how many VI-A companies send VI-A graduates back to M.I.T. for the annual interviewing process. This spring we welcomed the following: **Steven L. Bates,** '74, for GenRad; **Dean R. Collins,** '58; for Texas Instruments; **Chester M. Day, Jr.,** '57, for Bell Communications Research; **Daniel G. Jablonski,** '76, who became a proud father of a son in December, for the Naval Surface Weapons Center; **Anthony N. Nicoli,** '84, and **Vincent Palmermo, Jr.,** '83, for Honeywell Electro-Optics Division; **Carl M. Pietrzak,** '85, for Motorola; **Bernardo Rub,** '77, for Digital Equipment Corp., **Eric A. Slutz,** '74, and **L. Alan Snyder,** '73, for Hewlett-Packard Laboratories; and **Marc A. Zissman,** '85, for Lincoln Laboratory. . . . A note from **Lawrence Kernan,** '76, announced the arrival of a son in February. . . . A call from **Richard F. S. Williamson,** '84, told us he is now at Harvard working for a master's degree in math and science education.

Since last writing, visitors to the VI-A Office have included: **Daniel C. Cheng,** '81, with Data Resources and living in Natick, Mass; **David W. Duehren,** '80 and **Patrick T. Hynes,** '81, vice-presidents, respectively, for research and development and engineering for Brooktrout Technology Inc., Wellesley Hills, Mass.; **Thomas W. James,** '69, on campus interviewing for Hewlett-Packard, Andover, Mass.; **Thomas E. Knight,** '74, now with EMC Corp., Natick, Mass.; **Johnny Low,** '78, of Mitre Corp., **Juan C. Mercier,** '84, with Hewlett-Packard, Cupertino, Calif.; **H. DuBose Montgomery,** '71, who dropped in at the Student Open House, with Menlo Ventures, Inc., Menlo Park, Calif.; and **Lynn M. Roylance,** '72, interviewing for Hewlett-Packard Laboratories, Palo Alto, Calif.—John A. Tucker, Director, VI-A Internship Program, M.I.T, Room 38-473, Cambridge, MA 02139.

VIII PHYSICS

Thousands of school children know him as Captain Clement Granville, skipper of the *Mimi.* But around M.I.T. he's **Peter G. Marston,** head of the magnetohydrocynamics and high-energy physics magnet technology group at the Plasma Fusion Center. It all began when Marston learned about the need for a sailing craft for an educational television series. He volunteered his 72-foot ketch *Mimi,* and when the producers saw Marston's nautical profile and white beard they decided they wanted him *with* his boat. Now Marston is on a six-month leave from the Plasma Fusion Center to make a second TV series—an archeological expedition aboard *Mimi* to study the Maya off Yucatan.

The M.I.T. Laser Research Center, a project of the George R. Harrison Spectroscopy Laboratory of which Professor **Michael S. Feld,** '63, is director, holds the President's Award of the International Society for Optical Engineering. The citation is shared with a similar center at the University of Pennsylvania and one sponsored jointly in San Francisco by Stanford and the University of California.

J. K. Galt

M. T. Weiss

John K. Galt, Ph.D.'47, former vice-president of Sandia National Laboratories, and **Max T. Weiss,** Ph.D.'51, vice-president for the Engineering Group at Aerospace Corp., were elected to the National Academy of Engineering early this spring. Galt was honored "for important discoveries related to magnetic and composite materals, and for managerial leadership toward new optical device technology," Weiss for "extensive contributions to the research, engineering, and development of military space systems." Galt, having retired from AT&T Bell Labs is now at Aerospace Corp., El Segunda, Calif.

Eugene I. Gordon, Ph.D.'57, writes, "After retiring from AT&T Bell Labs after 26 years (at the age of 52), I started a company, Lytel, Inc., Somerville, N.J., that manufactures semiconductor lasers, LEDs, photo-detectors, transmitters, and receivers for fiberoptic communications. We are one and a half years into it and just beginning to deliver product. In 1984, I received the IEEE Edison Medal and Centennial Medal. 'Retirement' is very busy, fun, and exhilarating. I often wonder why I waited so long to take the step."

Daniel R. Cohn, Ph.D.'71, former head of the Fusion Systems Division of the M.I.T. Plasma Fusion Center, is director of the Center for Fusion Engineering and professor of electrical and computer engineering at the University of Texas, Austin. . . . **Frederick J. Marshall,** Ph.D.'82, writes, "I am presently working as a scientist at the University of Rochester Laboratory for Laser Energetics. Our laboratory has an ongoing program of research in inertial confinement fusion, using high-powered short-wavelength lasers to initiate hydrogen fusion reactions. Recently (April 1985), the LLE omega laser system set a benchmark in fusion research: the most fusion reactions from a laser target (2.1×10^{11})." . . . **William H. Lewis,** S.M.'51, who served on the staff of the Supreme Court of Michigan, passed away on June 3, 1985; no further details are available.

IX PSYCHOLOGY

Two members of the M.I.T. department were speakers in a public lecture series on cognitive science at the University of Arizona last year. Opening the series on September 18, **Edward Smith,** adjunct professor who is a senior scientist with Bolt, Beranek and Newman, proposed that most people's concepts are not really tight definitions but "prototypes"—images that are more visual than verbal. Later in the fall Professor **Susan Carey** spoke of her work in cognitive development as related to information science and the characteristics we describe as the "information age."

When the National Institute on Aging announced plans for a five-year $4 million program on Alzheimer's disease centered in Boston last year, it listed **Suzanne Corkin,** associate professor in the department at M.I.T., and **John Rosen,** research scientist, as major participants. Corkin will study disabilities in memory, language, and visuospatial function among Alzheimer's victims, and Rosen will establish and operate a data management facility for the new Massachusetts Alzheimer's Disease Research Center. One of

Corkin's major goals will be to correlate variations in brain chemistry and pathology with the progress of the disease, which differs widely in different patients.

X CHEMICAL ENGINEERING

Herbert H. Sawin, who came to M.I.T. in 1980 to work in the field of gas and solid surface reactions in the fabrication of microelectronic materials, has been promoted to the rank of associate professor; Sawin's degrees are from Iowa State and the University of California at Berkeley. . . . **Donald L. Koch,** an M.I.T. graduate student in chemical engineering, has received a NATO postdoctoral fellowship to continue work at Cambridge University, England.

Ronald T. Kurnik, Sc.D.'81, began medical school this fall at Washington University School of Medicine, St. Louis. . . . **Arnold F. Stancell,** Sc.D.'62, has been promoted to vice-president of planning in Mobil Oil Marketing and Refining, Greenwich, Conn. . . . **Manfred Gans,** S.M.'51, senior vice-president for technology at Scientific Design Co., New York City, is chairman of the United Nations Industrial Development Organization's Technical Assistance Committee for Petrochemical Research in Turkey.

Since retiring from Exxon in 1977, **Robert Dix,** Sc.D.'43, has devoted his full-time efforts to composing music for a variety of chamber ensembles and symphony orchestras. A lifelong musician, he began studies in composition at Julliard in 1970. Dix's work was featured along with that of five other composers last May at the final two Patrons' Musicales of the 1984/85 season of the Chamber Players of the Greenwich (Conn.) Symphony. The *Norwalk* (Conn.) *Hour* describes Dix's style as "lyric and romantic, with twentieth century harmonies."

John C. Quinn, Sc.D.'35, formerly principal staff engineer at Avco Systems Division, Wilmington and Everett, Mass., passed away on June 22, 1985. Prior to joining Avco, Quinn was director of research and development at Daystrom M.E.D. in Pennsylvania. His World War II service in radar and sonar led to an assignment as chief engineer of FCC's Foreign Broadcast Intelligence Service, and Quinn worked with the War Department and the Central Intelligence Agency, designing and supervising the installation of radio monitoring in the U.S. and Cyprus. . . . **Sudhanshu K. Dikshit,** S.M.'61, who was in the Plant Engineering and Development Division of the Indian Iron and Steel Co., Ltd., West Bengal, India, passed away in October 1982; no further details are available.

XI URBAN STUDIES AND PLANNING

Edward J. Logue, whose name is familiar to Bostonians for his role in the redevelopment of large sections of Boston in the 1960s, is senior lecturer in the department, working with the Center for Real Estate Development. He will teach a course in the field of redevelopment during the spring term. . . . **Anthony Mallows,** M.C.P.'81, registered architect and city planner, has been made an associate at Sasaki Associates, Inc., Watertown, Mass., in the fields of planning, landscape and urban design, and civil engineering.

The M.I.T.-Harvard Joint Center for Urban Studies has a new name—the Joint Center for Housing Studies—and its activities unrelated to housing research are being shifted to other groups at Harvard and M.I.T. The move recognizes the center's major thrust since 1981 into the field of housing problems and policies—but it means no change in the arrangements for joint sponsorship by Harvard and M.I.T. Professor H. James Brown of Harvard's Kennedy School of Government continues as director.

Frederick W. Todd, M.C.P.'68, is principal at Hammer, Kiefer and Todd, Inc., architects and planners, Cambridge. . . . **Rajinder H. Chanda,** '64, reports, "I have been working to promote low cost housing financed by the U.S. Agency for International Development in eastern and southern Africa."

Peter Homack, S.M.'41, principal of Elson T. Killam Associates, Inc., Millburn, N.J., passed away in January 1985 after a 40-year career as a practicing environmental engineer and professional planner in New Jersey. He joined Killam as an assistant engineer in 1945, and rose to be president of the 200-employee environmental engineering frim in 1965. Homack was honored as a fellow of the American Society of Civil Engineers and made a Diplomat of the American Academy of Environmental Engineers. He was a member of the Board of Overseers of New Jersey Institute of Technology, where he was responsible for instituting a Minority Scholar Program.

XII EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES

Robert M. Hazen, S.M.'71, a staff scientist and experimental mineralogist at Carnegie Institution, Washington, D.C., is the 1986 winner of the American Chemical Society's Ipatieff Prize. Hazen was cited for "his studies of changes in crystal structures that occur at high pressure and temperature." . . . **Karlene E. Davis,** S.M.'77, has joined the General Electric Research and Development Center, Schenectady, N.Y., as a materials analyst.

Philip H. Nelson, Ph.D.'67, has recently co-authored (along with Joseph Hearst) *Well Logging for Physical Properties,* (McGraw-Hill), which develops the technology for well logging, both for petroleum and mining, from fundamental principles. Nelson is currently employed by the Sohio Petroleum Co.'s Dallas Technology Center.

Allan H. James, Sc.D.'54, economic geologist and mining engineering passed away in Salt Lake City, Utah, on September 4, 1985. Following graduation, James joined the St. Joe Lead Co.'s Exploration Department, working in northern New York, Cuba and Mexico. He then joined Mount Hope Iron Mine near Dover, N.J., where he rose to general superintendent, and later went to Salt Lake City for the Kennecott Co., where he led pioneering mapping and stratigraphic studies in the Bingham copper district. James was then promoted to supervisory geologist, responsible for operating and developing mines in western United States, Chile, Alaska and British Columbia, taking an early retirement in 1972 to enter a

The Real Baldwin

We noted in this section in February/March (*page A21*) the tribute paid to Lionel V. Baldwin, S.M. '55, by the Congressional Institute for Space, Science, and Technology: Baldwin is president of the National Technical University and was honored for his success in using satellite broadcasts to bring master's degree course material into high-technology workplaces. We are

sorry to say that the photo that appeared with the story of his pioneering program was misidentified. The real Lionel Baldwin is shown at left.

consulting practice. He was president of the Utah Geological Society in 1968, a fellow of GSA, and a member of the Legion of Honor of the Society of Mining Engineers of AIME.

XIII OCEAN ENGINEERING

Lawrence W. McKinnon, administrative officer of the Sea Grant Program, is the author of *Getting Started with Lotus: Creating Spreadsheets, Graphs, and Charts*, a new Sea Grant publication. The book was stimulated by McKinnon's problems with all the existing manuals. He kept detailed notes of his solutions, and now these notes have been gathered into this book available for $10 from the Sea Grant Program, Room E38-302, M.I.T.

A one-year M.I.T. Henry L. Doherty Professorship in Ocean Utilization came to Assistant Professor **Dale G. Karr** early this year to support his ongoing work on the use of acoustic signals to characterize arctic ice. The idea is to observe microscopic changes in ice structures when loaded by such things as moving ships or offshore structures.

John R. Pauling, N.A.'54, professor of naval architecture at the University of California, Berkeley, was elected to the National Academy of Engineering early this spring. Pauling was cited for his "internationally recognized research in ship structures, ship hydrodynamics, and off-

XV MANAGEMENT

Pierre J. De Weck, S.M.'76, reports, "After six years in New York, we returned to Zurich to head the project finance team of Union Bank of Switzerland. Ziba is involved in a project to establish a contemporary art museum in Zurich . . . Philippe and Cyrus are busy learning German." . . . **Michael de Nevers,** S.M.'81, is working at the World Bank as an industrial economist and travels frequently to India and Nepal. . . . **Melford E. Monsees,** '58, reports that he is coordinator of the University of Missouri Graduate Engineering Program in Kansas City; has published a paper (July 1985)—"Executive Development of Young Engineers"; and is a member of the M.I.T. Educational Council. . . . **Don Fowke,** S.M.'63, write that he sold Hickling-Johnston Ltd., management consultants, of which he was co-founder and entrepreneur, to William M. Mercer, Ltd., Toronto, in January 1984. Fowke is currently director of Mercer and managing director of William M. Mercer-Medinger, Inc., New York, and is practicing strategy and organizational consulting in Canada and the U.S.

Roger Putzel, S.M.'70, is assistant professor of business administration at St. Michael's College, Winooski, Vt. Putzel previously taught graduate and undergraduate courses in personnel management at Boston College, McGill University, and L'Ecole des Hautes Etudes Commerciales (Montreal). . . . **Cyrus F. Gibson,** Ph.D.'69, is currently vice-president of Index Systems, Inc., Cambridge, responsible for the company's educational services and organizational change management practice. Gibson was formerly associate professor at the Harvard Business School where he specialized in organizational behavior, and he is author of *Managing Organizational Behavior*. . . . **Denis M. Slavich,** Ph.D.'71, has been elected a vice-president of Bechtel Group, Inc., San Francisco, and has been named chief financial officer; he's been with Bechtel since before completing his doctorate.

Sloan Fellows

Laurence S. Liebson, S.M.'79, is president of Xyvision, Inc., Woburn, Mass., producing computer-aided publishing systems and services serving both national and international customers. Xyvision last fall reported a major distribution agreement with the world's largest trading organization, the Marubeni Corp., to sell and support its wares to Japan. Liebson comments in *Mass High Tech* that the "agreement marks the first time a U.S. manufacturer has attempted to tap into the Japanese corporate market for computer-aided publishing." . . . **John D. Debbink,** S.M.'56, is currently vice-president and group executive of GM's Power Products Group and a member of the General Motors Administration Committee. He was formerly vice-president for GM's materials management staff. . . . **Peter B. Teets,** S.M.'78, is vice-president of Martin Marietta Corp., Bethesda, Md. Teets was formerly president of Martin Marietta's Denver Aerospace unit. . . . **William G.D. Frederick,** S.M.'80, acting director of the Sensors Office, Strategic Defense Initiative (SDI) Organization, Washington, D.C., gave the keynote luncheon address at the International Electronic Imaging Conference in Boston last October 9.

John H. Goldie, S.M.'65, writes, "Have taken an early retirement from the Boeing Co. after 36 years of service. Am plenty busy: on board of directors of a bank; doing some consulting; have begun to write a book; and have bought a winter home in Palm Desert, Calif. . . . **Hollis L. Caswell, Jr.,** S.M.'68, is currently senior vice-president at Burroughs Corp., Detroit, Mich., as well as president of the Burroughs Systems Product Group. . . . **Jon Leslie Fitch,** S.M.'70, of Indianapolis, Ind., passed away on September 8, 1985; no further details are available.

Senior Executives

Edward E. Barr, '69, received the 1984 Science/Technology Medal of the Research and Development Council of New Jersey for his service as chairman of the Governor's Commission on Science and Technology. . . . **Andrew C. Knowles III,** '76, president and chief executive officer of Lexidata Corp., Billerica, Mass., has been appointed to the Board of Directors of Ztel, Inc., Wilmington, Mass., which designs, manufactures, markets, and services the private branch exchange telephone systems. . . . **Lary G. Cahill,** '80, has been appointed a general manager in the Smelting and Refining Department of Asarco Inc., New York, N.Y., in charge of plants in Amarillo, Tex., Hayden, Ariz., and Tacoma, Wash. Cahill had been serving as assistant to the vice-president in the department since 1980. . . . **Frank N. Bien,** '62, retired on January 1, 1985, from the post of five-chairman of operations, American Electric Power Co., Inc., Columbus, Ohio. Also at American Electric Power, **Gene B. Hale,** '65, has been promoted from vice-president of personnel to senior vice-president.

Howell A. Breedlove, Jr., '76, resigned last July as president of Copperweld Corp., Pittsburgh, Penn. . . . **George H. Babikian,** '66, formerly senior vice-president of marketing at Atlantic Richfield Co., is now president of Arco Petroleum Products Co., a unit of Atlantic Richfield in Los Angeles, Calif. . . . **Jay H. Long,** '59, of Mt. Akum, Calif., passed away on July 15, 1985; no further details are available.

Management of Technology Program

Alan Drane, S.M.'85, and **David Hite,** S.M.'84, each called the Program office in February and expressed their congratulations and best wishes to Jane Morse, program manager, on the recent birth of her healthy eight-pound baby, Peter Morse Kernan. Peter was born on February 11. . . . **Koichi Kodama,** S.M.'84, was at the Sloan School for a business meeting in March and stopped by the office to meet Jacalyn Walker-Sharp. . . . Jacalyn ran into **John Piret,** S.M.'85, in Kendall Square in January. John is hard at work setting up his technology transfer business and is currently dealing with the problem of the high cost of product liability insurance.

Kunihide Oka, S.M.'85, wrote that he is busy in technical planning work in his former division of Yoshitomi Pharmaceuticals. He writes that his MOT experience gives him "a lot of power in decision making in technical management."

Rick Orr, S.M.'85, telephoned in February to report that he is now manager of cost reduction at L.T.V. Aerospace and Defense Co. Rick is in the Industrial Modernization Development Group and is currently at work installing a white-collar productivity measurement system. Sallee and Rick bought a home in Arlington, Tex., and were expecting their first baby March 19. . . . **Drew Peck,** S.M.'85, called Jacalyn in February and said, "Just call me Mr. Quote," in reference to his recent remarks cited in *Forbes*, *Fortune*, and the *Wall Street Journal*! Liz and Drew spent a day ice skating with Ruth and Alan Drane.—Jacalyn Walker-Sharp, Program Coordinator, Management of Technology Program, M.I.T., Room E52-125, Cambridge, MA 02139

XVI AERONAUTICS AND ASTRONAUTICS

The concept of inertial guidance credited to Professor Emeritus **Charles S. Draper,** '26, is among the 10 outstanding engineering achievements of the past half-century, says the National Society of Professional Engineers. Draper received NSPE's "Engineering for Gold" Award early this year in a program motivated by NSPE's 50th anniversary.

Michael Giles, Ph.D.'85, a specialist in computational fluid dynamics, **Stephen R. Hall,** Sc.D.'85, whose field is fault-tolerant systems, and **Daniel Hastings,** Ph.D.'80, an expert in the space environment, are completing their first year as members of the faculty. Giles is teaching the course in special topics in fluid dynamics, Hall has taught the Experimental Projects course and Computer Control of Dynamic Systems, and Hastings has worked with students in spacecraft-environmental interactions.

Thomas W. Laming, S.M.'84, writes, "Since receiving my degree from M.I.T., I have been working as a member of the Technical Staff in the Control Systems Engineering Department of TRW, Redondo Beach, Calif. In July 1985, my wife Jennifer gave birth to our first child, Thomas Alexander." . . . Rear Admiral **Wayne E. Meyer,** S.M.'61, a leader in the development of the Navy's revolutionary Aegis weapons system (to protect its aircraft carrier battle groups from multiple threats), retired late last year after 42 years of naval service. "Engineering is the battleground for keeping ahead . . . defense can match the threat, the nuclear shadow will not destroy us, and the United States can continue to lead the way," said Meyer during his retirement ceremony.

Don A. Coulter, S.M.'65, writes, "I have returned to the midwest after working for several years in Brazil where I was active in the planning and construction of the Rio de Janeiro International Airport, prepared proposals for international construction jobs, and worked for a consulting firm doing planning and design of an Alcoa Aluminum Refinery/Smelter. I am currently working for the Simulation Systems Division of Flight Safety International in Tulsa. My wife, Marina, and I and our three children (Eric, Lara, and Julie) reside in Tulsa."

Norman P. Hobbs, an authority on the effect of nuclear weapons who was vice-president of Kaman Sciences Corp. in Colorado Springs, passed away on October 17, 1984. Hobbs was also general manager and technical director of AviDyne Research, Inc., Burlington, Mass., a company founded by several former members of the M.I.T. Aeroelastic and Structures Laboratory. His main interests were in structures, aerolasticity, aerodynamics, guidance and control sytems, and instrumentation. Hobbs served as a member of the Defense Science Board in 1980. . . . **Bryan B. Brown, Jr.,** S.M.'56, of Vallejo, Calif., passed away on December 5, 1980.

XVII POLITICAL SCIENCE

Professor **Eugene B. Skolnikoff,** '49, will leave his post as director of the Center for International Studies as soon as a successor can be found. He's been director since 1972, and during this period he has focussed the Center's programs on "the critical effects of science and technology on international affairs." A rewarding effort, he says: M.I.T. "is unique among universities in its impact on international affairs and in its role as an international institution."

Professor **Willard R. Johnson** of M.I.T. is one of 24 specialists on Africa and foreign aid serving on the board of United Support of Artists for Africa (USA for Africa). His task: to oversee the distribution of 35 percent of USA for Africa's funds—much of them obtained through the "We Are the World" concert—designated for seed, fertilizer, farm implements, and irrigation equipment in drought-stricken areas of Africa. Johnson is a specialist in African politics and economic development; at M.I.T. he directs a program on the role of managers and institutions in promoting economic development in poor countries.

XVIII MATHEMATICS

Professor **Gilbert Strang** of M.I.T. believes that "applied mathematics can be taught in an active rather than a passive and old-fashioned way . . . My goal is to teach this subject as mathematics, looking for the ideas that are shared by a wide range of applications," he writes in explaining his new textbook, *An Introduction to Applied Mathematics* (Wellesley, Mass.: Wellesley-Cambridge Press, 1985). Strang is his own publisher. "I care too much about the subject, and about the effort that goes into teaching it and writing about it to, to mail in a manuscript and say goodbye," he says.

Professor **George Lusztig,** in the department at M.I.T., received the 1985 Frank Nelson Cole Prize in Algebra from the American Mathematical Society. . . . Professor **Anthony Ralston,** '52, of the Department of Computer Science at the State University of New York, Buffalo, is the editor of *Abacus,* a new journal in the field of computer science and technology published by Springer-Verlag. It's devoted, says the prospectus, to "current developments and trends" in the field for "the thinking professional, the sophisticated computer user, and the knowledgeable lay-person."

Victor W. Guillemin, professor of mathematics at M.I.T., was among 60 U.S. scientists elected to the National Academy of Sciences late last spring. And his M.I.T. colleague, Professor **W. Gilbert Strang,** '55, was chosen for membership in the American Academy of Arts and Sciences. . . . **David S. Jerison,** associate professor of mathematics at M.I.T., holds a $25,000 Sloan Foundation research award for 1985-86. . . . **Evarist Gine,** Ph.D.'73, is currently professor of mathematics at Texas A&M University and was elected a fellow to the Institute of Mathematical Statistics in 1984.

Horace A. Giddings, Ph.D.'34, of Daytona Beach, Fla., passed away on December 11, 1984. Giddings was chairman of the Mathematics Department at New York University, for 38 years.

XX APPLIED BIOLOGICAL SCIENCES

Assistant Professor **Renee Fitts** now holds the Henry L. Doherty Professorship in Ocean Utilization, under which she will exploit her recent discovery of a gene sequence in Salmonella that is unique and specific to all members of the genus—but not to other bacteria. Her goal is to devise a new monitor for coastal water contamination based on a hybridization assay for *E. coli* and other coliforms.

Professor **Gerald N. Wogan** of M.I.T. has been named to a new Board on Environmental Studies and Toxicology of the National Research Council. Replacing an Environmental Studies Board, the new group will oversee work on pollution sources, exposure pathways, health effects, and control techniques.

Elizabeth A. Williams, Ph.D.'76, received her M.D. in May 1985 from East Tennessee State University and began her residency in internal medicine there in July 1985. . . . **Dominick De Paola,** Ph.D.'74, is dean of the School of Dentistry in the University of Texas Health Science Center San Antonio. De Paola is a member of Sigma Xi, the American College of Dentists, the OKU honors dental fraternity, and the International Association for Dental Research.

Diana V. Garcia-Martinez, S.M.'78, has joined M.I.T. as an industrial liaison officer, bringing international industrial experience: she was responsible for the start-up of a New England fermentation plant for du Pont in the 1980s, when she was also a research associate at Tufts' New England Enzyme Center; earlier she was quality assurance manager of Enmex S.A. de C.V. and lecturer at the Instituto Politecnico Nacional.

Mary K. Kornreich, S.M.'70, writes, "I am now in my last year at Georgetown University Law Center and am working part-time in food and drug law." . . . **Charles L. Cooney,** S.M.'70, professor of chemical engineering at M.I.T., was given the James M. VanLanen Award of the American Chemical Society Division of Microbial and Biochemical Technology last September 10. The award recognizes service to the division; Cooney was cited for "leadership in many division roles and enthusiasm for the advancement of biotechnology . . ." . . . **John Reinhard, Jr.,** Ph.D.'80, has been promoted to research scientist IV in medicinal biochemistry at Burroughs Wellcome Co., Research Triangle Park, N.C.

XXIV LINGUISTICS AND PHILOSOPHY

Donca Steriade, Ph.D.'82, returned to M.I.T. last fall to join the faculty after three years as assistant professor of linguistics at the University of California, Berkeley; her teaching this year has been in the field of phonology, which is also her research interest.

TECHNOLOGY AND POLICY PROGRAM

Jeanne Briskin, S.M.'83, has been promoted to special assistant to the director of the Drinking Water Program in the U.S. Environmental Protection Agency. . . . **Deborah Estrin,** S.M.'83, completed her Ph.D. in computer science at M.I.T. last August and has joined the computer science faculty at the University of Southern California as an assistant professor. . . . **Carrick Brooke-Davidson,** S.M.'80, is working as an attorney in the Environmental Enforcement Section, U.S. Department of Justice.

Oswaldo Cortez, S.M.'81, is teaching at the University in Merida, Venezuela. . . . **Dave Rubin,** S.M.'83, is now a consultant with Pacific Gas and Electric. . . . **Jon Zilber,** is now manager of market research operations for Kessler Marketing Intelligence, Newport, R.I.

TPPS's award for the best thesis of 1985 went to **Claire Bischoff,** S.M.'85, who wrote on "The Role of Analysis in the Decision-Making Process in the Department of Mechanical Engineering"; and **Matthew Buresch,** S.M.'85, whose thesis was an engineering and economic analysis of residential photovoltaic generation in New England. Buresch is the author of *Photovoltaic Energy Systems* (Prentice-Hall, 1985).

I report with delight that **Bernard Rabinowitz,** '44, founder of Atlantic Industries, a world-wide leader in the manufacture of dyestuffs and colorants, has funded a group of graduate fellowships for TPP students—an evidence of Mr. Rabinowitz's strong personal support of TPP for which we're most grateful.—Richard de Neufville, Chairman, Technology and Policy Program, M.I.T., Room 1-138, Cambridge, MA 02139

D. V. Brown

M. J. Buerger

Douglass V. Brown, Jr., 1904-1986: Labor Economist and Arbitrator

Professor Emeritus Douglass V. Brown, Jr., whose expertise in industrial relations and arbitration influenced generations of students and had far-reaching effects on industrial policy, died on March 21 after a long illness. He was 82.

Brown came to M.I.T. from Harvard in 1938 and began almost immediately to take a leading role in shaping law and public policy dealing with the resolution of industrial conflict. He also served as a labor arbitrator, gaining public attention through rulings in controversial trucking and textile disputes. Later he headed an important study of labor relations and personnel administration in Boston's municipal government.

Brown became a leading figure on the faculty of the Sloan School and its predecessor School of Industrial Management by his success as a teacher and through studies of labor law, the nascent field of industrial relations, and the implications for labor of technological change and automation. Among pioneers in this area of study, he was president of the Industrial Relations Research Association in 1970-71.

At Brown's retirement, Howard W. Johnson, former dean of the Sloan School who was then president of the Institute, wrote, "Generations of M.I.T. students will remember many personal instances in which he counseled, prodded, pressed or queried—all in the interest of making it possible for his students to become what they truly were. Neither his time nor his patience had limits when it came to helping his students and his colleagues."

Before coming to M.I.T., Brown had been an economics instructor at Harvard, where he completed bachelor's (1925), master's (1926), and doctorate (1932) degrees. From 1933 to 1938 he was assistant professor of medical economics at Harvard Medical School. Brown retired to become professor emeritus in 1969 but continued to serve as senior lecturer at M.I.T. through 1974.

Martin J. Buerger, 1904-1986: Pioneering Crystallographer

Martin J. Buerger, '25, Institute professor and professor of mineralogy and crystallography, emeritus, died on February 25 of Alzheimer's disease at his home in Lincoln, Mass.; he was 82.

Buerger entered M.I.T. to study chemistry in 1920, and he transferred first to chemical engineering and then to mining engineering before receiving his S.B. But then he found the field in which he would become a preeminent leader during a 50-year career of teaching and research at M.I.T., receiving S.M. and Ph.D. degrees in geology and mineralogy, respectively, in 1927 and 1929.

Buerger's leadership came through his creation and direction of an x-ray diffraction laboratory devoted to crystal structure analysis. It was here that Buerger and his students developed methods for determining how individual atoms are arranged in patterns in crystals. This involved the development of sophisticated optical and mechanical instruments—Buerger is credited with the invention of at least two dozen of them—as well as important theoretical analyses. In all, 10 textbooks and more than 200 journal articles resulted, and Buerger became internationally known for this research as well as for the students who came from the laboratory.

Buerger's role in the field is now recognized by the Martin J. Buerger Award of the American Crystallographic Association; Buerger himself was honored by election as president of that association and of the Mineralogical Society of America, and he was a vice-president of the Geological Society of America. He held the Arthur L. Day Medal of the Geological Society, the Roebling Award of the Mineralogical Society, an honorary doctorate from the University of Berne, and foreign membership in the Brazilian Academy of Science for his assistance in starting crystallography at the University of Rio de Janiero.

A member of the faculty beginning in

1929, Buerger retired in 1973 but continued as a senior research associate for two more years, until 1975. He was made Institute professor in 1956 and from 1956 until 1963 served as director of a short-lived School for Advanced Study at M.I.T.

Memorial donations may be made to the Martin J. Buerger Student Aid Fund in care of the M.I.T. Alumni Fund.

John B. Babcock, 1889-1986: 48 Years in Civil Engineering

John B. Babcock, '10, professor emeritus of railway engineering in the Department of Civil Engineering, died in Portland, Me., on February 19; he was 96.

After completing his undergraduate work at M.I.T., Babcock worked for six years on railroad projects in Canada and then rejoined M.I.T. as a member of the faculty, from which he retired in 1954. In the meantime he had served as president of the Boston Society of Civil Engineers, secretary of the Engineering Societies of New England, and chairman of the Transportation Committee of the American Society of Civil Engineers. At the time of his death, Babcock was the oldest living honorary member of Chi Epsilon, the national civil engineering fraternity.

As a member of the faculty, Babcock was in charge of the department's courses in transportation, and he was for 25 years its placement officer, helping bring students and would-be employers together and counseling students on their career opportunities.

Babcock was awarded the Alumni Assocation's Bronze Beaver in 1979 for his long-time concern for alumni affairs and his leadership of alumni activities in Portland, Me., where he made his retirement home.

John F. McCarthy, 1925-1986

John F. MacCarthy, '50, former professor of aeronautics and astronautics, died suddenly in Los Angeles on February 7. He was 61, and at the time of his death was corporate vice-president and general manager of Northrup Corp.

In addition to his teaching post at M.I.T., McCarthy was for several years the founding director of M.I.T.'s Center for Space Research. Following receipt of a master's degree at M.I.T. (1951), McCarthy studied for his doctorate at Caltech (1962) and then joined NASA, where he won the agency's Distinguished Service Medal.

Pollack Memorial

A memorial service for the late Rabbi Herman Pollack, who died early this year, will be held in the M.I.T. Chapel at 3 p.m. on Sunday, May 18. Pollack was chaplain and Hillel director at M.I.T. from 1953 to 1971.

Violet B. Haas

Violet B. Haas, Ph.D.'51, who was visiting professor at M.I.T. in 1983-84 while serving as professor of electrical engineering at Purdue, died in Lafayette, Ind., on January 21 after a long illness; she was 59.

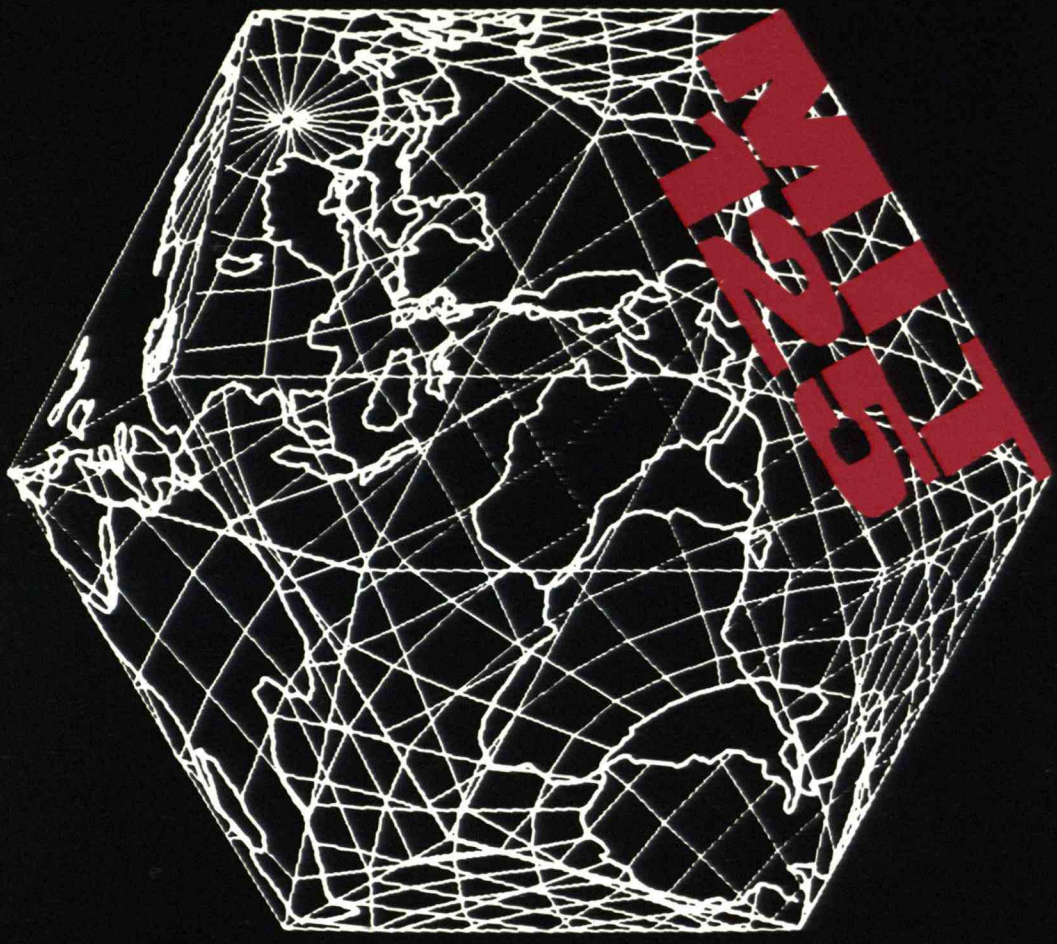
Haas had taught at Purdue since 1962; she was one of the campus' five "very important women" in a vote of the Purdue Association of Women Students in 1976. She was active in women's groups at M.I.T. while visiting professor as well as during her graduate study.

Among survivors are her husband, Felix Haas, '48, Purdue's executive vice-president and provost, and two children—Elizabeth Ann Haas, Ph.D.'79, of Cleveland and Richard Allan Haas, '73, of Worcester, Mass.

Deceased

The following deaths have been reported to the Alumni Association since the *Review*'s last deadline:

Harold S. Osborne, '08; December 29, 1985; Upper Montclair, N.J.
Edward M. Suess, '11; February 2, 1985; Saltillo Coah, Mexico.
Edmund S. Parsons, '16; January 19, 1986; Islamorada, Fla.
Ernest Palmer Giles, '18; March 1, 1986; Comfort, Tex.
John T. Elliott, '20; March 12, 1986; Newburyport, Mass.
Paul A. Morgan, '21; January 13, 1986; Lawrence, Mass.
Miles M. Zoller, '21; February 21, 1986; Tequesta, Fla.
William L. Hyland, '22; February 16, 1986; Norwood, Mass.
Robert C. Canby, '23; May 1984; Dayton, Ohio.
Edward J. Thimme, '23; February 15, 1986; Montclair, N.J.
G. Basil Blonsky, '25; December 2, 1985; San Jose, Calif.
Helmut W. Geyer, '26; January 17, 1985; Laguna Hills, Calif.
Thomas A. McLennan, '26; January 26, 1986; San Antonio, Tex.
Harry W. Pierce, '26; January 9, 1986; Woodstown, N.J.
Philip Robinson, '26; May 31, 1985; Downey, Calif.
George E. Wells, Jr., '26; 1983; St. Louis, Mo.
William W. Young, Jr., '29; December 7, 1985; Old Saybrook, Conn.
Hermann S.D. Botzow, '30; 1985; Stuart, Fla.
George M. Bunker, '31; November 5, 1985; Washington, D.C.
Jack T. Sherman, '31; December 24, 1985; Sedona, Ariz.
George K. Kerisher, '32; November 22, 1985; Westwood, Mass.
Edward V. Powell, '32; February 16, 1986; Marstons Mills, Mass.
Lester N. Stanley, '32; February 17, 1986; Venice, Fla.
Edward L. Bateman, Jr., '34; January 27, 1985; Sandton, South Africa.
Clifford E. Hentz, '34; December 16, 1985; North Billerica, Mass.
Edward C. Edgar, '35; January 28, 1986; Leesport, Penn.
Randolph L. Strickland, '35; July 22, 1985; Cresson, Penn.
Max Wasserman, '35; January 1, 1986; Cambridge, Mass.
Henry T. Gibbs, '37; February 16, 1986; Laguna Beach, Calif.
Walter A. Johnson, '38; November 9, 1985; Fort Myers Beach, Fla.
Robert B. Wooster, '39; Boynton Beach, Fla.
Herman A. Pieczentkowski, '40; July 31, 1985; Coronado, Calif.
Charles A. Hathaway, '43; November 22, 1985; Durham, N.H.
Russell G. Dickey, '47; January 1985; Del Mar, Calif.
Milton G. Hulme, Jr., '50; August 1985; Pittsburgh, Penn.
John F. McCarthy, Jr., '50; February 7, 1986; Yorba Linda, Calif.
Ralph E. Wolfe, '50; May 20, 1985; Pittsburg, Tex.
Matthias F. Comerford, '52; November 7, 1985; Newton Highlands, Mass.
Donald R. Kotansky, '62; January 9, 1986; Chesterfield, Mo.
Gary R. Tyler, '76; May 26, 1985; Parma, Ohio.
James M. Hagadus, '79; July 15, 1985; Bedford Hills, N.Y.



In 1986, MIT celebrates its 125th anniversary—its Quasquicentennial. This logo for the Quasquicentennial is based on Buckminster Fuller's Dymaxion Projection, a flat, distortion-free world map that can be folded into a cuboctahedron. The map is the product of an energetic, technically-oriented mind focused on the world at large. The same could be said for MIT. The practical concerns of the region, the country, and the world have shaped the programs and the priorities of the Institute since its founding. And in turn, the achievements of MIT's faculty, students, and alumni have had an enormous impact on the world around them. It is that involvement in human affairs that the MIT community celebrates this year, as it looks to its past and its future. Novelist Christopher Morley said of Fuller, his "innovations proceed not just from technical dexterity, but from an organic vision of life." That is also a commentary on work at MIT that the logo is designed to evoke and inspire.

Emma Savage, daughter of prominent Bostonian James Savage (seated at left, with James Savage, Jr. at right) married William Barton Rogers (standing) in 1849. The Savage fortune supported Rogers while he launched MIT, and a bequest from Emma later helped to buy MIT's Cambridge site.

MIT 125 YEARS

1861: The Charter-One Step in MIT's Evolution

On April 10, 1861, Governor John A. Andrew signed a legislative act granting a charter to the Massachusetts Institute of Technology and reserving for its use two-thirds of a square of state land in the Back Bay. Pivotal an event as that was, it was only one step in the process of defining MIT's character and form. It did, however, embody values that still shape the Institute 125 years later.

MIT's founders envisioned a three-part institution consisting of a "Society of Arts, a Museum of Arts, and a School of Industrial Science," with a view to aiding "the development and practical application of science in connection with arts, agriculture, manufactures and commerce." They expected that each of the three components would contribute significantly to the diffusion of useful knowledge. And as they emphasized on many occasions, it was not their intention to compete with neighboring institutions of higher learning.

The Museum was to be the "central feature," oriented towards the industrial interests of the region and appealing to "intelligent fellow-citizens in every walk of life." The Society of Arts was to be a "department of investigation and publication," promoting research and industrial science. And the School of Industrial Art and Science would provide systematic training in the applied sciences.

The catalyst for the initial effort to establish the Institute was the filling of Boston's Back Bay and the raising of acres of new land there awaiting development. By the spring of 1860, William Barton Rogers was asked to assume a leadership role as chairman of a committee seeking land for several societies as well as a committee to plan a polytechnic institution.

Rogers was a born teacher and a man of considerable stature as a geologist. While a professor at the University of Virginia, he had dealt effectively with a state legislature on matters of scientific and educational import, and he had developed educational plans for several technical institutions. He was an eloquent and persuasive speaker. His political instincts were finely honed. And it would be difficult to overestimate his commitment to the polytechnic institution for Boston.

To win public and legislative support, Rogers prepared the *Objects and Plan of an Institute of Technology*, turning for inspiration to the museums and conservatories of Europe, some of which included schools devoted to various disciplines. The document was addressed to "Manufacturers, Merchants, Mechanics, Agriculturists, and Other Friends of Enlightened Industry in the Commonwealth."

Encouraged by the document's favorable reception, Rogers' group pressed its petition for a grant of land and filed for a charter early in 1861. Throughout all the legislative hearings there was little question about the benefits such an institute would bring to the region. The grant of land was held up instead by a highly emotional political issue–the effect the grant would have on the state's School Fund, which was destined to receive the proceeds of the Back Bay sales.

As chief spokesman for the supporters of the Institute, Rogers testified, met with the Board of Education, and sought out key opponents. For good measure, he wrote the report of the legislative committee reviewing the relevant bill. When passage was finally secured on April 8, the Institute was given one year to become "duly organized," raise a $100,000 guarantee fund, and accept the charter.

On April 14 Fort Sumter surrendered to the Confederacy, and the country was plunged into civil war. It was not the most favorable moment to launch a new enterprise or to raise money for peaceful purposes, no matter how worthy. It would be a year before officers were elected, with Rogers as president, the charter accepted, and a one-year extension for the guarantee fund obtained.

The only segment of the Institute that could be inaugurated without considerable funding was the Society of Arts, which held its first meeting on December 17, 1862. The meetings attracted enthusiastic audiences, content to be informed about scientific and technical advances

which were only beginning to transform their lives. The meetings continued into the early twentieth century, but the ambitious plans for advancing technical knowledge under the aegis of the Society of Arts never became a reality.

The organization of the Museum was severely hampered by the magnitude of its mission and the lack of prior consideration about how a vast array of disparate collections and machinery was to be gathered, housed, maintained, and kept current.

Fortunately, the governing board gradually began to look more closely at the School; it was an important turn in the history of MIT, brought on chiefly by the need for money.

On July 2, 1862, President Lincoln had signed the Congressional Land-Grant Act, also known as the Morrill Act, through which a fund would be created by each state for the endowment of "at least one college where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts. . . ."

While the Institute was preparing to seek help from this source, Governor Andrew gave enthusiastic support to a Harvard proposal that Massachusetts seize this opportunity to create "a great university in Cambridge." This new entity would be formed by combining the School of the Institute, still not under way, with Harvard's Lawrence Scientific School and its planned Bussey Institution for practical agriculture.

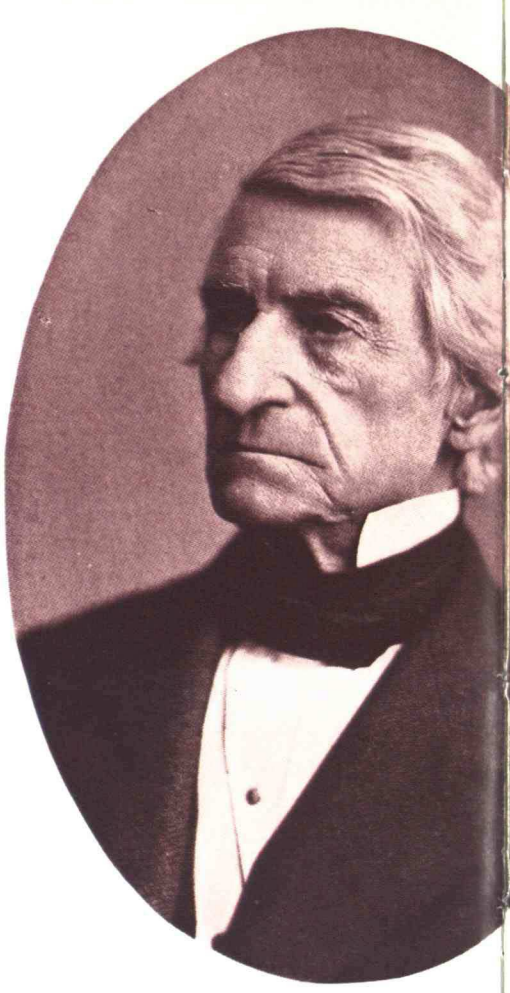
Rogers, however, was firm that "the Institute had from the beginning determined to stand alone, that its independence was essential to its success, and that it would accept no grant from the State, or from any other quarter, which should in the slightest particular interfere with this independence." His arguments and those supporting the establishment of a state agricultural college prevailed.

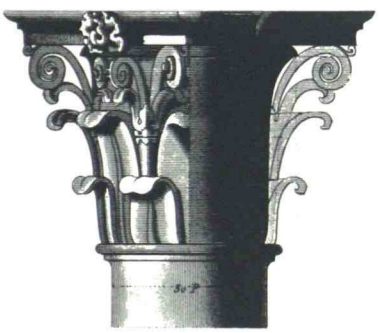
A charter amendment on April 27, 1863, provided to MIT a one-third share of the annual income of the state's land-grant fund, thereby making it a land-grant institution. Though this was a significant victory, the amounts later received from this source never equalled the initial expectations. But in convincing a legislative committee of the need for and the importance of their School, Rogers and his associates had ensured that this component of the Institute would be their major focus for the future.

Meanwhile, the extended year for raising the $100,000 guarantee fund was running out. A drive launched in February, 1863, produced only $40,000, and requesting a further extension would have prejudiced the Legislature's decision on the use of the land-grant fund. At the last moment, Dr. William J. Walker, a wealthy retired physician, announced that he would complete the guarantee fund, assuring MIT's immediate survival.

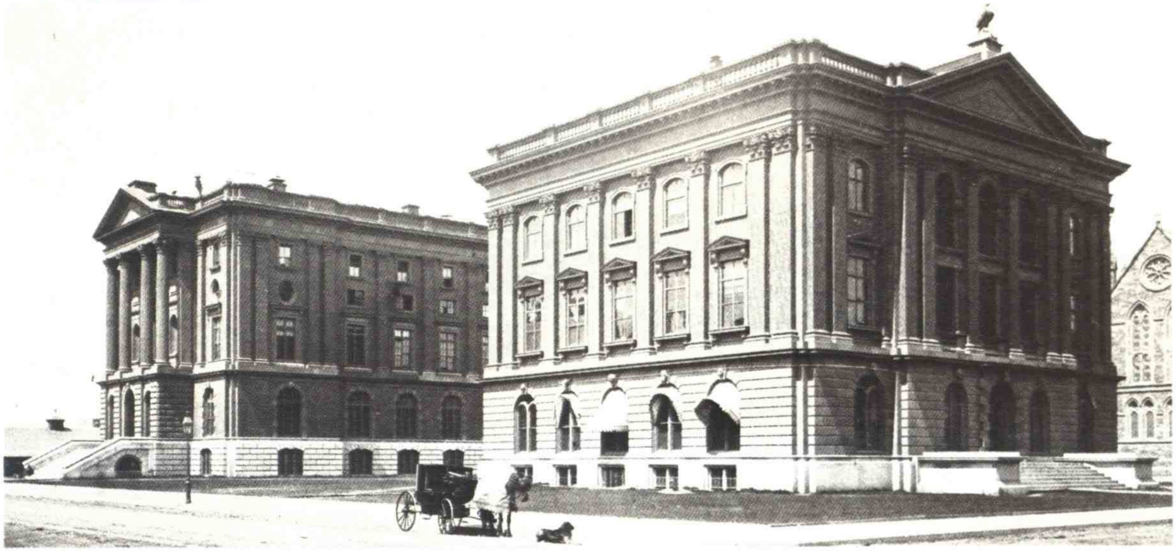
Yet another year passed before Rogers completed the *Scope and Plan of the School of Industrial Science*. It was a practical document, outlining the School's early structure, the courses of study, and the teaching methods. Just as important, it embodied the tenets of Rogers' educational philosophy: that there is dignity in the mastery of useful knowledge; that science is fundamental to the progress of technology and that together they can contribute significantly to human welfare; that the learning process must be active, for direct experience gives life and meaning to knowledge; and that professional training may profitably be combined with a liberal education in the undergraduate years, to the enrichment of both. Above all, he firmly believed that these objectives were best achieved through a special kind of institution, independent and with a clear perception of its central mission.

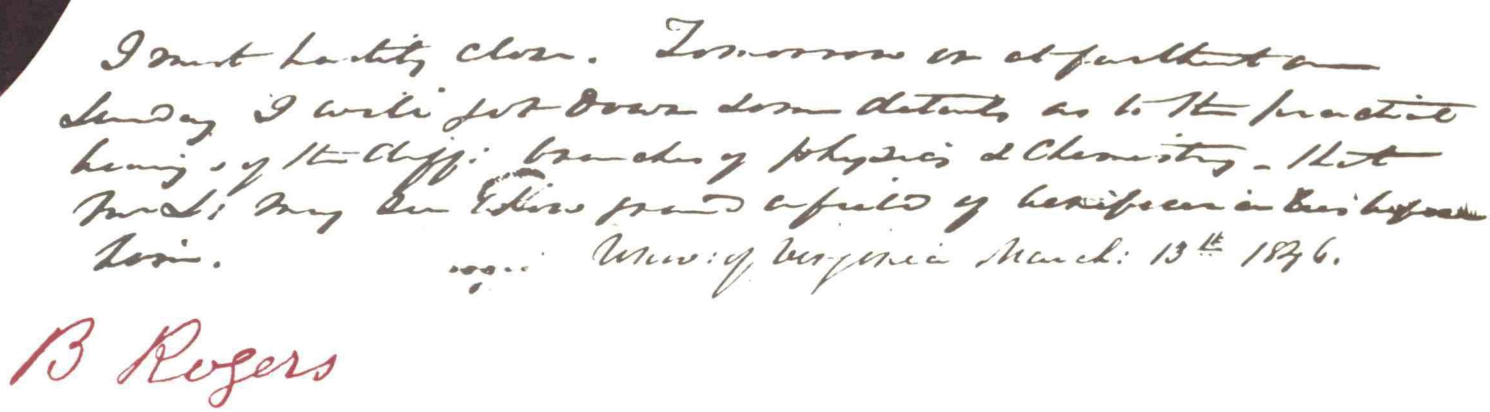
A preliminary session of the School began in February, 1865, and the first regular session opened in October with 72 students and a faculty of ten. By 1888 the catalogue would state that "the SCHOOL OF INDUSTRIAL SCIENCE, developed along the lines indicated at its foundation, has become the prominent feature of the work of the Institute; and indeed, nearly all persons know it, and it alone, as the Institute."





MIT's first building (below, left) shared its Copley Square site with the Massachusetts Society of Natural History, now the Bonwit Teller building on Boylston St. As early as 1846, while still teaching at the University of Virginia, William Barton Rogers (left) was writing to friends of his ideas for an institute of technology.





125 Years of MIT and World History

1861
April 10: Governor Andrew signs act chartering the Massachusetts Institute of Technology and granting block of land in Back Bay, to include "a Society of Arts, a Museum of Arts, and a School of Industrial Science"

April 12: Fort Sumter bombarded; Civil War begins

Congress levies first income tax; money used to support Union forces

1862
Fifty-four incorporators elect William Barton Rogers first president of MIT; Institute organized and begins to function as a Society of Arts

Lincoln issues Emancipation Proclamation

Leon Foucault measures speed of light

Pasteur develops "germ theory"

1863
Institute secures portion of state's Morrill Act funds, becoming a land-grant institution

William J. Walker gives $60,000 to complete guarantee fund and save Institute charter

Construction of the Institute's first Back Bay building begins

National Academy of Sciences established

Definitive rules for soccer drawn up in England

1864
William Barton Rogers' "Scope and Plan of the School of Industrial Science," outlining proposed organization and plan of instruction, adopted by Corporation of Institute

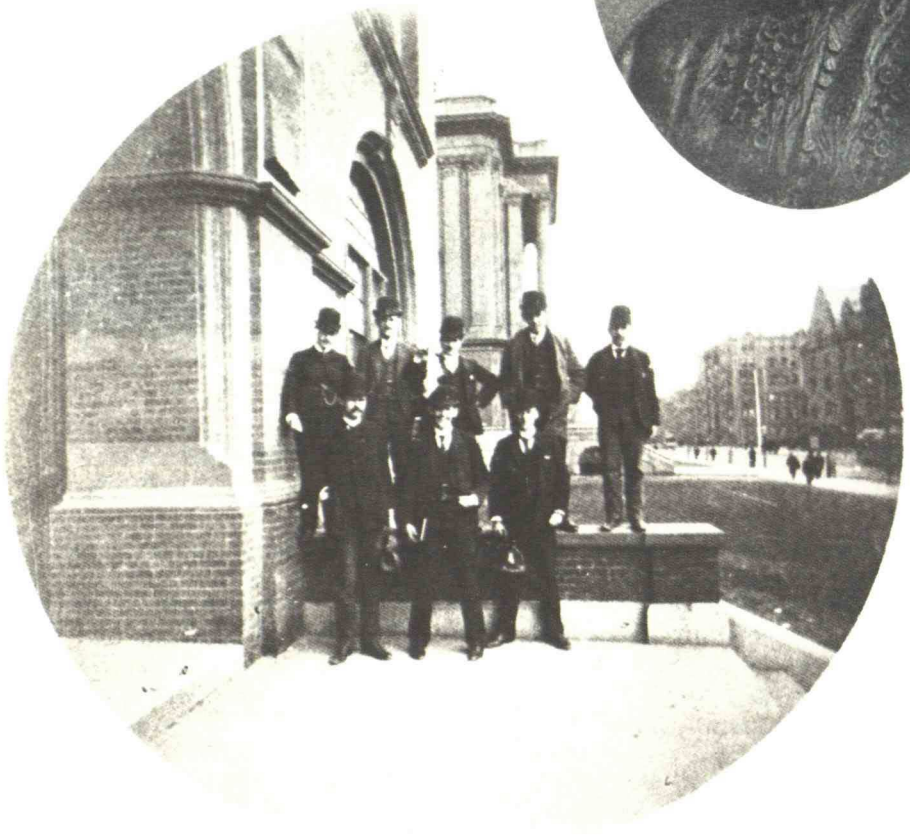
Corporation approves official seal of Institute

Theta Xi, professional engineering and science fraternity, founded

James Slater patents drive chain

On February 20, 1865, the first classes were held in rented space in the Mercantile Building in downtown Boston. Studies offered were "suited to the various professions of the Mechanician, the Civil Engineer, the Builder and Architect, the Mining Engineer, and the Practical Chemist"

1882:Local School Makes Good with Hero at Helm



Ellen Swallow, (above) received the S.B. degree in chemistry in 1873. Wed in 1875 to Professor Robert Richards, '68, she taught chemistry at the Institute until the day she died in 1911. She was a national leader in the home economics and public health movements, and helped found the American Association of University Women. Ellen (far left, back row at right) was a key figure in the launching of the Women's Laboratory.

(Above) "A bunch of electricals" on the steps of MIT's first Walker Building, in 1890. The view is down Boylston St.

1865
Eli Forbes enrolls as first student

April 9: Lee surrenders to Grant at Appomattox

April 15: Abraham Lincoln assassinated

Gregor Mendel enunciates his "Law of Heredity"

1866
MIT Building in Back Bay completed and occupied; later named in honor of William Barton Rogers

Tuition:
$100 for first-year students, $125 for second-year students, $150 for upperclassmen

Alfred Nobel invents dynamite

Mount Washington cog railroad construction begun

1867
Charles W. Eliot and Francis H. Storer publish *Manual of Inorganic Chemistry*, which revolutionized teaching of subject; one of a long line of textbooks from MIT that shaped whole fields of study

Alaska is purchased from Russia for $7.2 million

Georges Leclanche invents practical dry-cell battery

1868
MIT Department of Architecture enrolled four students; this is the first program in architectural instruction in the United States

William Barton Rogers suffers stroke at faculty meeting; John D. Runkle appointed acting president

First graduating class of 14 receives Graduate of Institute degrees with course designation

1869
Edward C. Pickering develops physics teaching laboratory

Charles W. Eliot becomes president of Harvard and soon urges merger with MIT

Suez Canal opens

Transcontinental railroad completed

William F. Semple patents chewing gum

Fifteen years after the first classes, however, affairs of the young technical institute in Boston were not overly promising. The prolonged depression triggered by the Panic of 1873 had left MIT struggling for faculty, students, space, and money–not necessarily in that order.

At the same time, America urgently needed technically-trained college graduates to maintain the momentum of the 19th century growth industries: railroads, textiles, steel, roads, machines, and mining.

Stretched tautly between need and opportunity, MIT had the wisdom–and luck–to name Francis Amasa Walker as president. Walker was a celebrated professor of political economy at Yale's Sheffield Scientific School, a pioneer in statistical science who had directed two U.S. censuses, and a decorated Civil War officer. At the time he took office at MIT, to judge by newspaper editorials about him, Walker was one of America's most admired public figures.

In a 16-year presidency, Walker expanded faculty, boosted enrollments, quadrupled space, and attracted important gifts. By all accounts, he transformed MIT from a school of regional importance to one of national and international stature.

In 1869, young Walker, retired from the Union Army as a brigadier general at age 25, was appointed chief of the Bureau of Statistics. Within a month of his appointment, Walker had assisted Congressman James A. Garfield, later President, in drafting legislation for the 1870 census. At age 29, he was made census superintendent by President Ulysses S. Grant. The census completed, Walker served Grant as Commissioner of Indian Affairs until December, 1872, when he was appointed to the Yale faculty.

During the 1870s, his reputation as writer and lecturer soared. He published widely, including books on wage theory, monetary policy, and land valuations. As the 1880 census neared, President Rutherford Hayes asked Walker to direct it, since Walker had again worked

1870
William Barton Rogers resigns presidency because of ill health

John D. Runkle becomes second president and remains steadfast in belief that MIT must remain independent from Harvard

Atlantic City boardwalk erected

DNA is discovered

1871
Ellen H. Swallow, having graduated in chemistry from Vassar College, admitted as special student in chemistry

Alexander Graham Bell moves to Boston, attends lectures by Lewis B. Monroe and works in physics laboratory with Edward C. Pickering and Charles R. Cross '70 on sound and acoustics problems

Portland cement invented

1872
Great Boston Fire destroys business district; student battalion patrols after fire

MIT degree title changes to Bachelor of Science with course designation

Advanced courses established

Eadweard Muybridge catches motion in photographs

Yellowstone National Park authorized

1873
First student publication, *The Spectrum*, begins monthly publication

Joseph F. Glidden patents barbed wire

U.S. adopts gold standard

Economic Depression of 1873

1874
Practical experience in laboratory, shop, and field espoused by John D. Runkle leads to student summer visits to engineering and mining operations

First formal graduation exercises held

French impressionists show paintings in Paris

Margarine introduced in U.S.

1875
Robert H. Richards '68 founds Alumni Association and is elected first president

Gym classes begin in MIT's new gym and drill building

George F. Green invents electric dental drill

with Garfield in drafting the legislation. Walker, on leave from Yale, was thus engaged in the spring of 1880 when he was recruited for the MIT presidency by an aging William Barton Rogers.

Walker's tenure lasted until his death in January, 1897. Under his leadership, enrollments, which had edged back to 300 in 1881, would grow to near 1,200 in 1897, drawing students from 40 states and 20 foreign countries. Annual income went from $72,000 to $327,000. He wooed key donors, and raised endowment from $137,000 to $1.8 million. The teaching staff grew from 38 to 128, 52 of professorial rank.

Graduate programs were inaugurated, as were summer field programs. Three principal buildings were added to the one that housed the Institute upon Walker's arrival. Budgets were balanced, faculty salaries progressively increased, monies made available for research. It was a golden era for M.I.T.

But Walker's legacy would be more than numbers.

With industrialization and consequent urbanization in the latter half of the 19th century, Americans faced massive problems in public health and disease control. During Walker's tenure, MIT biologist William T. Sedgwick, who began the nation's first course of pre-medical studies, proved that typhoid fever is spread through the disposal of raw sewage into rivers and streams.

(Below, left) John D. Runkle, Rogers' first teaching colleague at the Institute School and MIT's second president. (Right) Francis Amasa Walker, a national figure when named MIT's third president.

1876
Women's Laboratory opened in cooperation with Women's Education Association of Boston, provides for special instruction in chemistry, mineralogy, and related subjects

Alexander Graham Bell gives first demonstration of telephone to MIT's Society of Arts

Cardinal red and silver gray chosen as MIT colors

1877
Runkle establishes School of Mechanic Arts based on Russian system of training through shopwork

Swan boats appear in Boston Public Garden

Nathaneal G. Herreshoff '70 patents catamaran

Edison invents phonograph

A. Downs and T. P. Blunt discover germicidal properties of ultraviolet rays

1878
Runkle resigns because of poor health; William Barton Rogers again accepts presidency with conditions that $100,000 be raised to ensure Intitute's stability and that a search for a successor begin immediately

Howard A. Carson '69 becomes first alumnus elected to Corporation

Second attempt by Harvard to absorb MIT as its engineering school

1879
Grade reporting system changes from numercial system to:
H = passed with honor
C = passed creditably
P = passed
F = failed

Edison invents practical incandescent lamp

Women obtain right to practice law before U.S. Supreme Court

1880
American Society of Mechanical Engineers founded

New York City population exceeds one million

Halftone photographic illustrations appear in newspapers

1881
Francis Amasa Walker, economist, becomes third president

1882
William Barton Rogers dies while speaking at commencement exercises

Charles R. Cross '70 offers first electrical engineering course in Department of Physics

Sigma Chi, first social fraternity at Institute, established

Charles H. Kip proposes Harvard Cooperative Society

At its zenith in 1887, the MIT football team was "universally admitted to be the strongest eleven in New England outside of Yale and Harvard." (At left, the Football Eleven of 1894.) In 1901 President Pritchett disapprovingly commented that the students at Tech had no time for practice or games, and football was voted down. Finally, in 1978, a group of students braved predictions of crushing expense and indifference to successfully launch a club football program.

Robert R. Taylor was the first black to receive an MIT degree, in 1892.

Griffen and Little, a chemical engineering research firm, opened in Cambridge in 1886. Soon to be known simply by the name of its founder, Arthur D. Little, class of 1885, it was one of the earliest MIT "spin-off companies." Seventy years later, Robert Everett, '43, founded the MITRE Corporation and Kenneth Olsen, '50, (left) founded Digital Equipment Corporation (DEC), two more recent examples of a tradition of putting an MIT education to entrepreneurial use.

Taken from a balloon in 1860, the first aerial photograph of Boston (below) includes the Mercantile Building, site of MITs first classes.

(Right) George Eastman, photography pioneer and Institute benefactor.

1883
Biologist William T. Sedgewick launches at MIT the nation's first course of premedical studies, to give future doctors a solid grounding in fundamental science

Brooklyn Bridge opens

Alexander Graham Bell founds *Science* magazine

1884
Biology Laboratory established

Association formed to play intercollegiate football with Williams, Amherst, and Tufts

Washington Monument completed

Charles Parsons tests first practical steam turbine

Lewis Waterman invents fountain pen

1885
First student yearbook, *Technique*, published by Class of '89

Pasteur creates vaccine against rabies

George Eastman produces coated photographic paper

William Stanley and George Westinghouse perfect transformer for electrical networks

Leland Stanford, Jr., University founded

1886
First advanced degree, a Master of Science in chemistry, given to Frederick Fox, Jr., '85

Statue of Liberty unveiled

Jacob's Pharmacy, Atlanta, Georgia, introduces Coca-Cola

Electric welding process invented

1887
Thomas A. Edison gives Institute a dynamo and 150 lamps to use in teaching electrical engineering

Ellen Swallow Richards, class of 1873, MIT's first woman graduate, was appointed an instructor in sanitary chemistry in 1884 and began her long career as the founder of home economics and environmental protection (she coined the word "ecology" as applied to the environment).

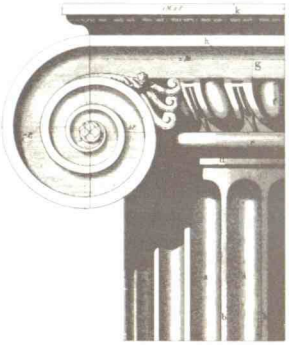
It was during Walker's term that MIT offered the nation's first classes in electrical engineering and chemical engineering and the first degree program in naval architecture.

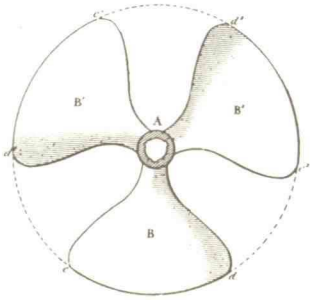
Walker strengthened the humanities and social sciences, and he gave the Institute's first course in economics. Moreover, by his appointments, he enlivened courses in English and foreign languages, giving the cultural aspects of an MIT education a new importance.

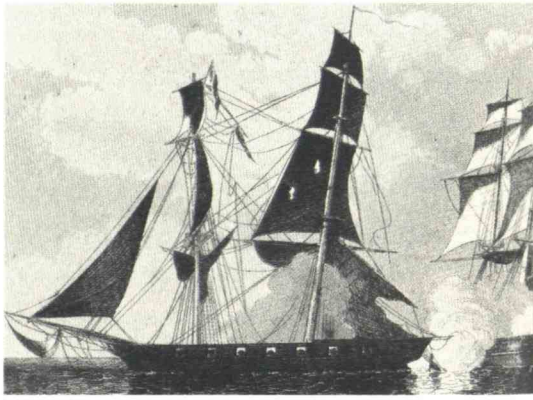
From Walker's MIT came graduates who could and did captain the engineering and technological enterprises that transformed America and the world–among them such figures as Alfred P. Sloan, '95, who organized and led the giant General Motors Corporation; Gerard Swope, '95, who headed the General Electric Company; and the financial and business management pioneer, Roger Babson, '98.

Granted, it was an in-house opinion, but biologist Samuel Prescott, writing a history of MIT in 1954, would judge that by the end of Walker's tenure, the Institute had become "the leading school of engineering and applied science in the Western Hemisphere, and possibly without peer in the whole world." Heady talk about an institution that had been operating less than 35 years.

1916: "He Found Rome Brick and Left it Marble"







(Left to right) Mechanical engineering students from the Class of 1876.

Detail from an early text.

The variable-pitch propeller blade of the Wright Brothers Wind Tunnel, opened in 1938.

The instructing staff of the chemistry department, c. 1900.

Richard Cockburn Maclaurin, sixth president of MIT, c. 1910.

1888
First classes in chemical engineering offered by Lewis M. Norton

Engineering Building built to house Mechanical and Civil Engineering Departments

First commercial aluminum produced

Alexander Graham Bell publishes *National Geographic*

1889
Department of Natural History becomes Department of Biology

School of Mechanic Arts discontinued

Uncoached Tech football team wins intercollegiate pennant

1890
Geology splits from Mining Engineering to become a separate course

1892
First Black student graduates from MIT: Robert R. Taylor, Course IV

Enrollment reaches 1,000

Rudolph Diesel patents an internal combustion engine

Sierra Club founded

1893
Department of Naval Architecture established by Cecil H. Peabody '77

Cataloguing of library holdings accomplished

First open-heart surgery performed

Henry Ford builds his first car

Economic Depression of 1893

1895
William Lyman Underwood '96 and Samuel C. Prescott '94 begin studies that will provide scientific foundation for modern canning

W. K. Roentgen discovers X rays

Arthur A. Noyes '86 establishes *Review of America Chemical Research*, later called *Chemical Abstracts*

It would be said of Richard Cockburn Maclaurin, MIT's sixth president, that, like Caesar Augustus, he found Rome brick and left it marble.

Maclaurin–mathematician, physicist, lawyer–became president of MIT in 1909 at the age of 39. It was he who raised funds to build the New Technology, steered the Institute through controversy surrounding the selection of its new site in Cambridge, superintended planning and construction, and, in 1916, amid pageantry and celebration, led MIT from its origins in Back Bay to its present location on the north shore of the Charles River Basin.

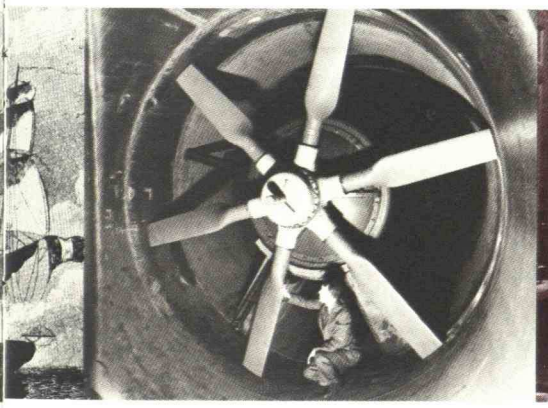
When Maclaurin came to the presidency, MIT had a clear case of growing pains. Nearly 1,500 students. Sixteen buildings scattered from Copley Square to distant locations in Brookline and Roxbury. A teaching staff of 300. Its facilities were by no means a match for the national and international reputation MIT had acquired for excellence and rigor in engineering instruction.

What's more, MIT was still recovering from an institutional trauma. In 1904, MIT President Henry S. Pritchett and Harvard President Charles Eliot, together with a majority of MIT and Harvard trustees, had determined to merge MIT with Harvard, despite vigorous opposition from MIT alumni and faculty. The plan depended on MIT's selling its property in Copley Square for a handsome price. When courts ruled that such a sale would violate terms under which MIT had originally received the properties, the merger was dropped. Rebuffed, Pritchett left in 1907, and MIT needed a new leader.

Leadership, in the form of Maclaurin, arrived by an unconventional route. Born in Scotland, raised in New Zealand, and educated at Cambridge, England, Maclaurin came to the United States in 1908 to take up a post in the physics department at Columbia University. But his tenure there was destined to be short. Among the first American scientists he met was George V. Wendell, '92, president of Stevens Institute of Technology. On the strength of Wendell's recommendation, Maclaurin was elected MIT's sixth president, effective June, 1909.

Before he even took office, Maclaurin recognized that MIT simply had to find a new home, and he knew that would be his central task.

On an April, 1909, visit to Boston, Maclaurin saw the basin that had resulted from the Charles River Dam and the barren lands on the Cambridge side that had been formed with fill taken in the recent dredging of the basin. The site struck Maclaurin as ideal for size, accessibility, and dignity of setting.



1896
Small wind tunnel with speed of 15 mph built by students under guidance of Gaetano Lanza using air current from Institute's ventilating system

Henri Becquerel discovers radioactivity

Olympic Games revived in Athens

1897
Francis A. Walker dies suddenly

James Mason Crafts, world-renowned for Friedel-Crafts Reaction, takes charge of Institute as chairman of faculty and is later elected fourth president

J. J. Thomson discovers electron

First running of the Boston Marathon

First portion of Boston subway opens

1898
Students form "Tech Battalion" and offer themselves for Spanish-American War duty

U.S. annexes Hawaiian Islands

Marie and Pierre Curie isolate radium

Zeppelin builds airship

1899
First Tech Show

Alumni Association launches publication of *Technology Review*

Boll weevil crosses Rio Grande

Stanley Steamer automobile climbs Mt. Washington

Felix Hoffman and Hermann Dresser perfect aspirin

1900
Henry Smith Pritchett, astronomer and mathematician, inaugurated fifth president

Cane Rush ends in death of student; this event replaced by Field Day

Max Planck formulates quantum theory

General Electric founds Industrial Research Laboratory, supervised by Willis R. Whitney '90

1901
Intercollegiate football team disbanded by student vote of 119 to 117

Guglielmo Marconi sends wireless messages across Atlantic

National Bureau of Standards established

U.S. College Entrance Examination Board conducts first tests

He immediately encountered resistance. Bordered on the north by rough and unsightly industrial buildings, the filled lands would shortly be overrun by more of the same, he was told. Moreover, Cambridge, already chafing about the amount of tax-free land Harvard owned, would surely object to still another educational institution in its midst. Or so it was believed.

However, widespread public attention was attracted to MIT in 1910 by newspaper accounts of an MIT-sponsored Congress of Technology. In the afterglow, the Cambridge City Council extended a formal invitation for the Institute to relocate there. A similar invitation came from Springfield, Mass. Even Chicago was in the running, with newspapers there urging "Boston Tech" to consider moving to the Windy City. More and more, the public was coming to identify the future prosperity of the nation with technology.

By 1911, popular opinion had swung to the Cambridge site that was Maclaurin's first choice. Over that year, Maclaurin had secured gifts and grants sufficient to acquire the Cambridge site, and the following year he spent raising the funds necessary to erect the New Technology's buildings.

The key gift was $2.5 million from an anonymous donor, "Mr. Smith," later identified as George Eastman, founder of Eastman Kodak Co. Eastman's gifts to MIT during Ma-

MIT's move from Boston to Cambridge in 1916 was the occasion for spectacular celebrations. Costumed bearers carried the charter in a carved chest to an elaborate barge, the "Bucentaur," for a trip across the Charles, landing amid rockets and search-lights. In the pageant "Masque of Power," Man, assisted by Science, subdues Nature, and a banquet in Symphony Hall was linked by Bell's telephone with alumni celebrations in 34 cities.

1902
Henry S. Pritchett introduces beer and music at new Tech Union, to dismay of local community

Department of Electrical Engineering founded

Rayon, "artificial silk," patented by Arthur D. Little '85 and Harry S. Monic

Binney and Smith introduce Crayons

1903
Lydia G. Weld '03 becomes first woman to receive engineering degree (in naval architecture)

Arthur A. Noyes '86 organizes Research Laboratory of Physical Chemistry

Lowell Institute School begins evening classes with MIT faculty serving as instructors

Automobile crosses U.S. in 65 days

Wright brothers fly at Kitty Hawk

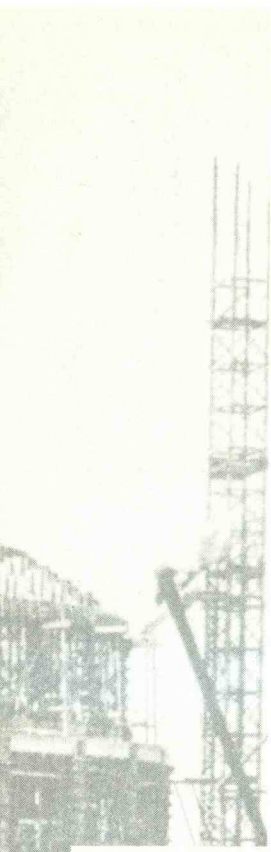
1904
Rhodes Scholars program launched

Harvard-Tech student riot injures 50

1906
Research Laboratory of Applied Chemistry formed by William H. Walker

Lee DeForest invents three-element radio vacuum tube

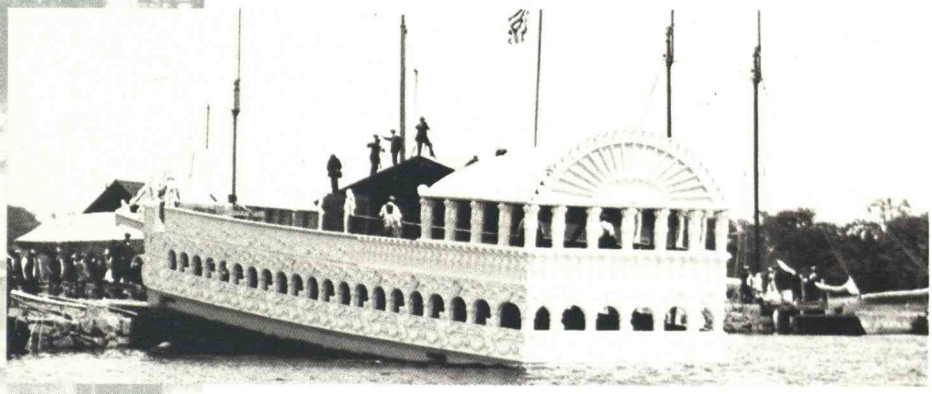
1907
First Ph.D.'s granted to three students in physical chemistry

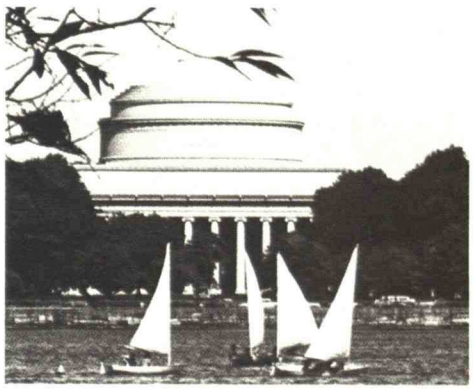


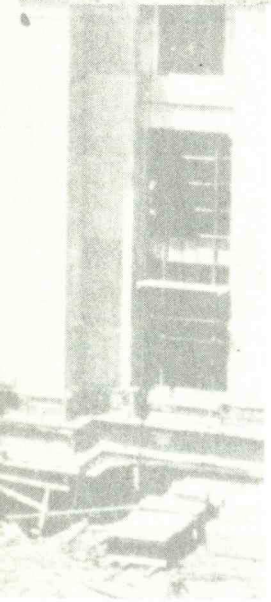
A Harvard-MIT merger was proposed in 1904, one of several such proposals in the Institute's history. The faculty and alumni objected, but the Corporation voted for the merger. The Massachusetts Supreme Court held that the Institute could not sell its land in the Back Bay, however, and thereby killed the plan. In response to the threat of merger, the first all-tech Alumni Reunion was held, and the alumni set up a five-year plan to raise funds to meet Institute needs.

MIT's original campus was in Copley Square, on the site of the present New England Life Building. Overcrowding led several presidents to seek another location in such places as Allston, the Fenway, and even Springfield. The filling of the Charles River Basin and an initial $2,500,000 donated by the mysterious "Mr. Smith (George Eastman) enabled MIT to begin building on the present site in 1913.

The unusual set of interconnected buildings was designed by Welles Bosworth and constructed by Stone and Webster, all MIT alumni. Bosworth designed MIT's main entrance through the Great (Killian) Court into Lobby 10, intending that Boston would look across the Charles and gaze on the limestone pillars in awe. Building 7, fronting on Massachusetts Avenue, was not added until 1938, when the School of Architecture joined the rest of the Institute in Cambridge.







1908
William Coolidge '96 produces ductile tungsten for incandescent lamp

Model T rolls off Ford assembly line

1909
Richard Cockburn Maclaurin, physicist and mathematician, inaugurated sixth president during Second All-Tech Reunion

MIT Aero Club formed

1910
Civil Engineering Summer Camp at East Machias, Maine, established

Barney Oldfield drives Benz 133 mph

Charles River Dam completed

1911
Congress of Technology, celebrating 50th anniversary of MIT charter, draws national attention to quality of Institute graduates

1913
Jerome C. Hunsaker '12 initiates aeronautical engineering course

Lincoln Highway opens; first coast-to-coast paved road

Neils Bohr formulates theory of atomic structure

1914
Davis R. Dewey organizes course in engineering administration

Beaver becomes official MIT mascot

1916
"The New Technology" dedicated; 4,000 alumni attend Third All-Tech Reunion

Vannevar Bush receives Doctor of Engineering degree, fifth to be awarded

Einstein announces his General Theory of Relativity

Blood is refrigerated for transfusions

Margaret Sanger opens birth-control clinic

1917
U.S. enters World War I; specialized schools for Army and Navy aviators, aviation engineers, and radio engineers organized on campus in support of World War I effort

Sigmund Freud writes *Introduction to Psychoanalysis*

claurin's presidency would eventually reach $20 million.

In 1913, work started on MIT's new home with W. Welles Bosworth, '89, as architect. Construction would require three years. On June 13, 1916, MIT's move was marked by a public extravaganza.

But Maclaurin presided over more than construction and theatricals. In his tenure, three advances occured in geology and mining for which MIT would long be remembered.

In 1909, Professor Robert H. Richards, '68, published his landmark four-volume study on the dressing of mineral ores, a work that proved of inestimable value to miners and minerals processors.

In 1912, Thomas A. Jaggar, Jr., made major advances in seismic exploration of the earth's crust, studying the relationships between volcanoes and earthquakes.

In 1913, Waldemar Lindgren published the world's first authoritative text on the origins of ores, a vital aid in mineral exploration.

There were important happenings in still other areas. In 1909, for example, MIT began the nation's first formal course of instruction on the internal combustion engine.

In 1913, Jerome Hunsaker, '12, a naval architect and mechanical engineer turned aviation pioneer, inaugurated America's first college program in aeronautical engineering. One of the first students was airplane builder Donald Douglas '14.

And, in 1914, with Maclaurin's inspiration, MIT began the teaching of "engineering administration," a course of study that would be known as industrial management.

Upon Maclaurin's death at the age of 49, George Eastman wrote: "I feel the loss of such a man is almost irreparable, not only to Technology, but to our country as well. As I have talked to him and learned of his plans and ambitions for Tech and its place in the development of this country, I can estimate in a measure the tragedy of losing him....

"Helping to make those plans possible...has appealed to me as an opportunity to get considerable sums of money into effective action for the benefit of the whole country...."

The Division of Industrial Cooperation, formed in 1919, had its roots in two chemical engineering programs: the Research Laboratory of Applied Chemistry, founded in 1906, and the School of Chemical Engineering Practice, begun in 1917 by Arthur D. Little (below), class of 1885. Both were pioneering attempts to integrate industrial experience into an academic program and stressed the utility of academic research to industrial firms. DIC is now known as the Office of Sponsored Research.

1918
Emma Rogers Organization of Technology Women formed by Margaret Alice Maclaurin, now called Women's League

Harlow Shaply measures Milky Way

Regular Air Mail service established; Earle Ovington '04 first pilot

World War I ends

Great Influenza Epidemic

1920
"Mr. Smith" revealed to be George Eastman

Richard C. Maclaurin dies of pneumonia

American women get vote

Prohibition becomes law

1921
Pratt School of Naval Architecture and Marine Engineering Building (5) completed

Herbert T. Kalmus '03 develops technicolor process

1922
Edward L. Bowles '22 and Carlton E. Tucker '18 develop concepts for communications curriculum

Lincoln Memorial dedicated; statue by Daniel Chester French '73

1923
Class of '23 introduces caps and gowns at commencement

Samuel W. Stratton, director of U.S. Bureau of Standards, inaugurated eighth president

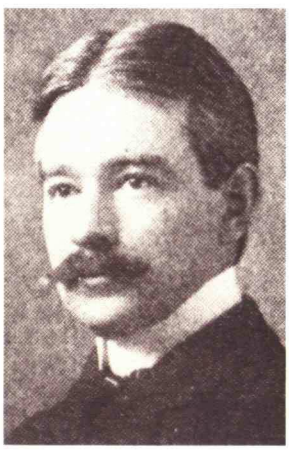
1924
Edwin H. Blashfield '69 begins murals in Walker Memorial

Patent for iconoscope (TV) issued to Vladimir K. Zworykin

1925
George Eastman gives $4.5 million as unrestricted gift to MIT

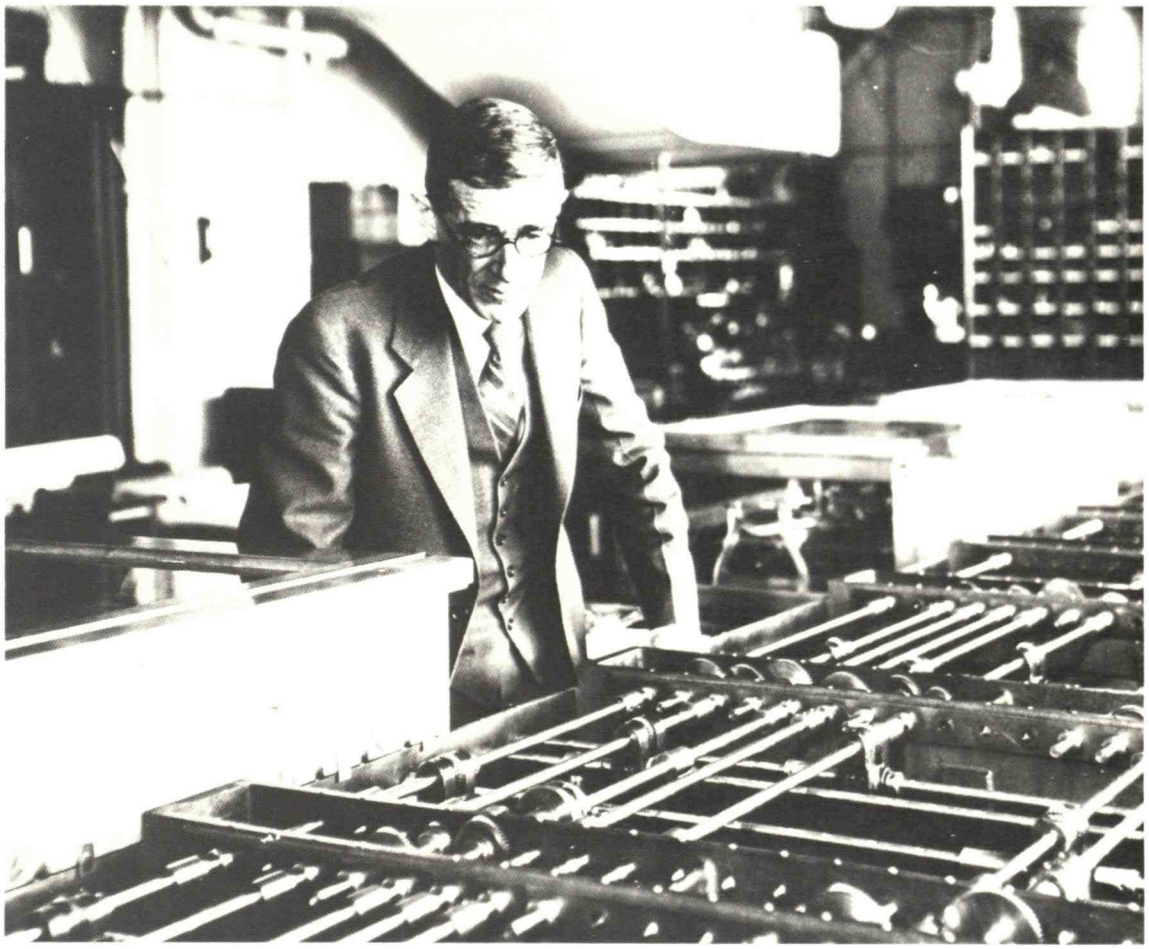
Hitler publishes *Mein Kampf*

Cosmic rays discovered in upper atmosphere



(Below) William H. Walker was one of the founders of chemical engineering and the first director of the Division of Industrial Cooperation and Research.

Vannevar Bush '16, Herbert R. Stewart '24, and Frank D. Gage '22 built the product integraph, the Institute's first analog computer, in 1925. With Harold Hazen and others in the forefront, MIT assumed an early lead in electronics and computer science. In the 1920s and '30s MIT electrical engineers developed several prototype integraphs, rapid selectors, and differential analyzers. (Bush is shown below with a differential analyzer.)



1926
James R. Killian, Jr. '26, joins *Technology Review* staff

Goddard launches first liquid-fuel rocket

Kodak produces 16mm movie film

1928
Carl-Gustaf A. Rossby establishes meteorology course

War outlawed; 65 nations sign Kellog-Briand Pact

Alexander Fleming discovers penicillin

First scheduled television broadcast

1929
Committee selects Standard Technology Ring featuring beaver ("Brass Rat")

Nationwide highway numbering system adopted

Black Friday; stock market crash

William Green develops automatic pilot

1930
Karl Taylor Compton, physicist, inaugurated as ninth president; Samuel W. Stratton, first chairman of Corporation

New Department of Business and Engineering Administration formed

Planet Pluto discovered

1931
Differential analyzer based on design by Vannevar Bush '16 put into operation

1932
Eastman Laboratories (Bldg. 6) completed to house Departments of Physics and Chemistry

Vannevar Bush '16 becomes MIT's first vice-president

Tuition raised from $400 to $500 per year

Amelia Earhart flies solo across Atlantic

James Chadwick discovers neutron

Edwin Land invents synthetic light polarizer

1934
Harold E. Edgerton '27 and Kenneth J. Germeshausen '31 devise electrical circuitry making possible high-speed photography

1935
115-foot Cape Cod Canal model built by Civil Engineering for environmental study

1937
Department of Mining Engineering becomes Department of Metallurgy

1938
Gordon S. Brown '31 develops cinema integraph, another stage of the "thinking machine" based on the theories of Norbert Wiener

1939
Vannevar Bush '16 appointed chairman of National Defense Research Committee by President Roosevelt

Hoyt C. Hottel '24 and Albert G. H. Dietz '32 design first MIT solar house

1930: Compton Lured from Princeton to Revolutionize Engineering

(Top to bottom) Karl Taylor Compton, president from 1930 to 1949.

Harold "Doc" Edgerton, '27, founder of high speed photography.

Gordon Brown, '31, innovator in engineering education.

In the late 1920s, science was changing dramatically, and it was apparent to those with vision that engineering education would have to keep pace. Among those who wished to advance science, mathematics, and graduate education at MIT were Gerard Swope, '95, president of the General Electric Co., and Frank Jewett, '03, president of Bell Telephone Laboratories, both members of the MIT Corporation. It was Swope who proposed that Samuel W. Stratton, president since 1923, assume the newly-created post of chairman of the MIT Corporation and that a new president be recruited.

Caltech had earlier upgraded science and mathematics with impressive results. So Jewett asked colleagues there for suggestions about people who might do the same at MIT; they recommended Karl Taylor Compton.

Contacted by Swope in early 1930, Compton had every reason to decline. At age 42, he had been a Princeton physics professor for a decade and had only months before assumed the prestigious chairmanship of the department there. The immediate past president of the American Physical Society, Compton had studied in Europe as quantum theory was taking shape. His own research had marked him as one of the foremost authorities on the physics of electric discharges in gases, the field that would soon be known as plasma physics. He was reluctant to give up science to pursue administration, particularly at an institution where physics was not near the top of the academic pecking order.

But before rejecting MIT's offer, Compton sought advice from Jewett, whom Compton had come to know and respect when they had worked together on committees of the National Academy of Science. Jewett was in Washington, about to return by train to New York. Compton joined him when the train reached Trenton, New Jersey, and they talked en route. Compton later recalled: "I told my wife I was pretty sure I would turn the job down; and, in fact, Dr. Jewett did nothing positive to try to influence me.

"He said that he had observed some things about engineering schools in the United States. They had performed a useful function several decades ago and had done a marvelous job, in his opinion, but that they were far behind in their usefulness in the present and particularly in the future.

"They were too much on the pattern of technical trade schools. The only solution was to try to inject into the policies of these institutions a greater interest in fundamental science and research, if someone could be found to do it.

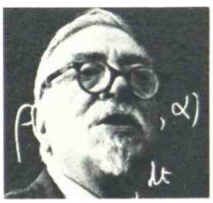
"So I thought it was up to me to try to help," Compton concluded.

Compton's first steps at MIT were to recruit a group of gifted young physicists to strengthen that department. From Harvard to head the MIT department came the 29-year-old theoretical physicist, John Slater, who had studied with Denmark's Niels Bohr. From Stanford came the experimental physicist, George Harrison; his Spectroscopy Laboratory would become world-famous for the encyclopedic MIT Wavelength Tables that listed the spectral emission lines for virtually all species of atoms then known. And from Princeton came Robert Van de Graaff of electrostatic generator fame and Philip Morse, who would become a pioneer in operations research.

The faculty continued to grow in physics, chemistry, biology, and mathematics through the 1930s. By the end of that decade, MIT would be recognized as an important national resource both in science and engineering and would be strategically positioned to render major national service during World War II and in the decades that followed. Of equal importance, MIT's teaching programs became models for other engineering schools throughout the U.S.

In Compton's great legacy to MIT–he would serve as president until 1949 and as chairman until his death in 1954–must be counted his inspirational dedication to public service. His speeches, essays, and annual reports bristle with allusions to the societal obligations of science and engineering. He measured himself and MIT in terms of national purpose and social advancement.

1940: Some Say the War Was Won at MIT



(Top to bottom) James R. Killian, Jr., '26, president from 1949-59.

Julius A. Stratton, '23, president, 1959-66.

Mathematician Norbert Wiener, considered the most universally recognized professor in MIT's history.

The destiny of the modern Massachusetts Institute of Technology was permanently altered on October 17, 1940, at a secret meeting at Washington's Wardman-Park Hotel. It was there that a subpanel of the National Defense Research Committee (NDRC) urged MIT President Karl Taylor Compton to locate the radar development program at MIT.

As it would turn out, the radar program, carried on by the wartime Radiation Laboratory at MIT, would become America's second largest technical effort of World War II. It was surpassed in size only by the Manhattan atomic bomb project. Lee DuBridge, who became director of the laboratory (and later president of Caltech), would say in hindsight that radar won World War II; the atomic bomb only ended it.

Top news on the morning of the Wardman-Park meeting was about the 14 million American men, 21 to 35 years old, who had registered with Selective Service Boards the day before in this nation's first peacetime draft. But there were those who knew the U.S. was generally ill-prepared for war, that victory would not be quick or even certain. These included key members of America's scientific inner circle, among them MIT's Compton, Harvard President James Conant, and Vannevar Bush, '16, president of the Carnegie Institution of Washington, D.C., and a former MIT vice-president.

In June, 1940, Bush persuaded President Roosevelt to establish the NDRC to contract with universities and industry for defense research. Bush envisioned NDRC as the framework within which science and technology could be mobilized to support military operations. It was an imaginative plan. The federal purse, up to that time, had not provided much funding for university research, which had relied primarily on foundation support. What's more, universities, by tradition, conducted "pure" research; applied research was the work of industry and government laboratories.

Bush became the NDRC chairman. Compton headed the NDRC division focused on detection, controls, and instruments, and he had assigned specific areas to subpanels.

Radar was not new. But it had not become particularly useful or widespread because of problems with long wavelengths and low power. Then, in mid-1940, came a stunning breakthrough: Scientists at the University of Birmingham in England succeeded in building a resonant cavity magnetron tube that produced 10-centimeter radiation at an intensity several thousands of times greater than the most advanced American tube.

Britain urgently needed 10-cm radar for fighter planes then locked in nightly combat with German bombers. So, in September, a British mission brought the magnetron to Washington, hoping American science and industry could quickly develop the practical applications.

Bush and Compton placed the magnetron before the radar panel with instructions to get going. The Microwave Committee, as the group was soon named, began the search for people and for a facility.

The panel persuaded 50 top physicists to join the effort and selected DuBridge from the University of Rochester to be director. The name "Radiation Laboratory" was selected to mislead espionage agents; from that name the enemy might conclude that the project dealt with nuclear physics, at that time a scholarly, non-military subject.

But efforts to secure a research site near Washington had failed. Finally, the committee, augmented by Bush himself, asked Compton if MIT could accept the project and invited him to breakfast at the Wardman-Park to talk about it.

Compton's initial hesitation stemmed from two concerns. First, selection of MIT might appear to others as favoritism. He was chairman of the cognizant NDRC division and he was president of MIT. How would that look?

The committee argued that there was good reason to think of MIT for the radar project. For starters, the effort would require strength in both theory and application, precisely what had been achieved at MIT in the decade Compton had been president.

Perhaps more important to Compton, however, was the suggestion that the federal government sponsor a major project laboratory on a university campus. Commonplace today, it was then novel and posed a potential threat to academic independence and freedom of scholarly inquiry.

The committee argued that NDRC was, itself, academic in character and could be relied on to uphold academic principles insofar as wartime conditions would permit. The important point was that the nation was at peril. War seemed inevitable, and America could lose.

Before the morning was over, Compton had agreed to place the project at MIT. Within days of the Oct. 17 meeting, physicists recruited from colleges and universities all over America began arriving at the Institute.

Before war's end, Rad Lab would develop 150 different radar sets for the armed forces, as well as the LORAN long-range navigation system. The laboratory grew to a staff of 1,200 scientists and engineers and another 2,700 technicians and support people occupying temporary buildings along Vassar St. In addition, MIT would train 9,000 servicemen to operate radar.

Radar was not MIT's only technical contribution to the war effort. Servomechanism systems to control batteries of guns, gyroscopic gunsights, underwater mine detonators, special metals for the atomic bomb, antisubmarine technology, aerial flash photography, blood chemistry, battle field nutrition, and many more fields felt the impact of MIT's wartime service.

Rad Lab also left a special impression on MIT. MIT's interdisciplinary Research Laboratory of Electronics, the first of the peacetime federally-supported research centers now found widely among major American universities, was formed from the Rad Lab's research division at war's end. Moreover, Rad Lab made research an equal partner with teaching on the MIT campus and nurtured at the Institute a special style: energetic, bold, decisive, open to the novel and the unexpected.

1957:Our Thanks to "Sputnik," It Was an Inspiration

On November 7, 1957, a troubled President Dwight D. Eisenhower gave a TV speech to the American public that catapulted into national focus not just MIT,but all of America's scientific and engineering enterprises.

Toward the end of his speech, Eisenhower announced the appointment of MIT President James Rhyne Killian, Jr., '26, to the newly-created post of Special Assistant to the President for Science and Technology, the first White House "science adviser." Killian's career as a highly visible national figure had begun and, by association, MIT would share celebrity with him.

The appointment was seen historically as the launch of an era in which science and engineering assumed greatly expanded roles in America's peacetime culture. It was accompanied by significantly increased federal funding; the National Science Foundation budget, for example, jumped from $58 million to $136 million in one year. The overall effect was to trigger rapid and stunning advances in virtually all basic and applied sciences from subnuclear physics to astrophysics, from molecular science and manipulating of genes to the dynamics of the earth's own inner core. Science would become popular.

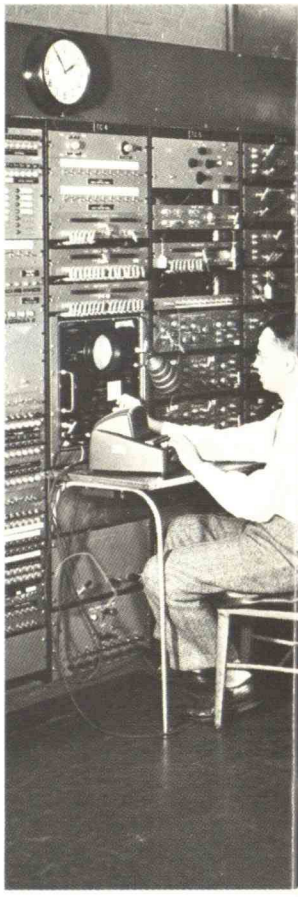
As Eisenhower began his speech, most Americans were still reeling from a Russian one-two punch. On Oct. 24, the USSR had launched "Sputnik," the first artificial satellite, a 184-pound sphere beeping triumphant radio signals back to earth. They followed a month later with a 1,000-pound satellite carrying a live dog.

To many, it appeared the Russians had taken over world technological dominance. America, on the short end of a "missile gap," could expect soon to be held hostage by

Reporters mob Killian at a press conference following announcement of his appointment as White House science advisor.

Known first as Engineering Administration, Course XV was launched in 1914. Supported by the vision and resources of Alfred P. Sloan, '95, (above) Course XV became in 1952 the School of Industrail Management, which was renamed for Sloan in 1965. Its students fulfill an early prediction that "future executives will need to know more about science and technology . . . will need the powers of rigorous analysis that we have come to associate with MIT."

The Research Laboratory of Electronics, peacetime sequel to the Radiation Laboratory, was established in 1946. RLE quickly became an internationally recognized center for basic research in the fields of electronics, general physics, phasing dynamics, and communication sciences and engineering. The founding of RLE represented a major departure in the organization of academic research. Recognizing that emerging fields of science often cut across disciplinary lines, RLE supplemented traditional departmental laboratories by affording a common meeting ground for science and engineering and for the pure and applied aspects of basic research. It led to the development of similar interdisciplinary centers at MIT and elsewhere.



1942
Development of molecular biology begins under Francis O. Schmitt

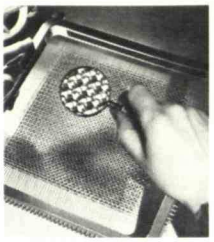
Bell Aircraft tests first U.S. jet

Enrico Fermi demonstrates self-sustaining nuclear chain reaction

1944
Mark I computer developed at Harvard

Allied troops land on Normandy beaches; D Day

Working in 1949 in MIT's Servomechanism Laboratory on aircraft flight simulation, Jay W. Forrester, '45 (below, second from left) developed a new information storage system comprised of ferrite cores. The result of this work, the magnetic core memory, (right) represented a breakthrough in computer storage capabilities. Forrester's Whirlwind Computer, based on core memory, became the precursor for the modern high speed digital computer.



Launched in 1963, Project MAC (Multiple-Access Computer and Machine-Aided Cognition), was directed by Professor Robert Fano, '41, and Fernando Corbato, '56 (immediate left). It sought to develop the new technique of time-sharing, to simplify computer languages for easier and broader access, and to increase the potential educational uses of computation machines. By 1976, when it became the Laboratory for Computer Science, Project MAC had developed MULTICS and made great strides in computer graphics. Project Athena, begun in 1983 to test the impact of high-powered student workstations in all subject areas of the undergraduate curriculum, is also expected to trigger dramatic breakthroughs in the application of computers.

Shortly after the construction of I.M Pei's Green Building for Earth, Atmospheric and Planetary Science in 1964, Alexander Calder was commissioned to create La Grande Voile (The Big Sail-shown above) to be placed in front of the building. The monumental stabile has become the work of art most closely identified with MIT. MIT's Permanent Collection of more than 1,600 contemporary works includes an extensive collection of outdoor public art that has been described as one of the most significant in New England.

1945
Department of Food Technology organized

Women's residence opens at 120 Bay State Road

Franklin Roosevelt dies, Harry S. Truman becomes president

May 8, V-E Day

August 14: Hiroshima

1946
Research Laboratory of Electronics, peacetime sequel to Radiation Laboratory, was established

Laboratory for Nuclear Science and Engineering established

Carbon 13 discovered

United Nations General Assembly holds first session

ENIAC, the first automatic electronic digital computer is developed at the University of Pennsylvania

1948
Norbert Wiener publishes *Cybernetics*

Peter Goldmark invents long-playing record

1949
Winston Churchill speaks at Mid-Century Convocation on social implications of scientific progress

James R. Killian, Jr. '26 inaugurated tenth president

1950
Alfred P. Sloan ('95) Foundation grants $2,250,000 to launch School of Industrial Management

School of Humanities and Social Science established

1951
Course in nuclear engineering organized

Center for International Studies established

$25,668,532 raised during Mid-Century Development Fund Drive

1952
Lincoln Laboratory develops plans for Distant Early Warning (DEW) line; subsequently SAGE (Semi-Automatic Ground Environment) digital computers are used to assimilate DEW line data

Jerome B. Wiesner and William H. Radford '32 develop tropospheric scatter for over-the-horizon communication

1953
Inertial guidance system developed by Charles S. Draper '26 monitors pilotless flight from Massachusetts to California

1954
Lightweight crew wins Thames Challenge Cup at Henley

Atomic-powered submarine launched

Supreme Court rules segregated schools unconstitutional

Polio vaccine and contraceptive pill developed

orbiting Russian bombs. Killian recalled later that the Sputniks had produced a "climate of near hysteria." Eisenhower's TV speech, entitled "Science and Security," ended with the assurance that Killian's appointment would "make sure that the very best thought and advice that the scientific community can supply...is now fully organized...so that no gap may occur."

Killian's appointment was evidence that the American public and its leaders recognized that science had to be weighed along with domestic politics, social and economic concerns, international statecraft, and defense in setting national priorities.

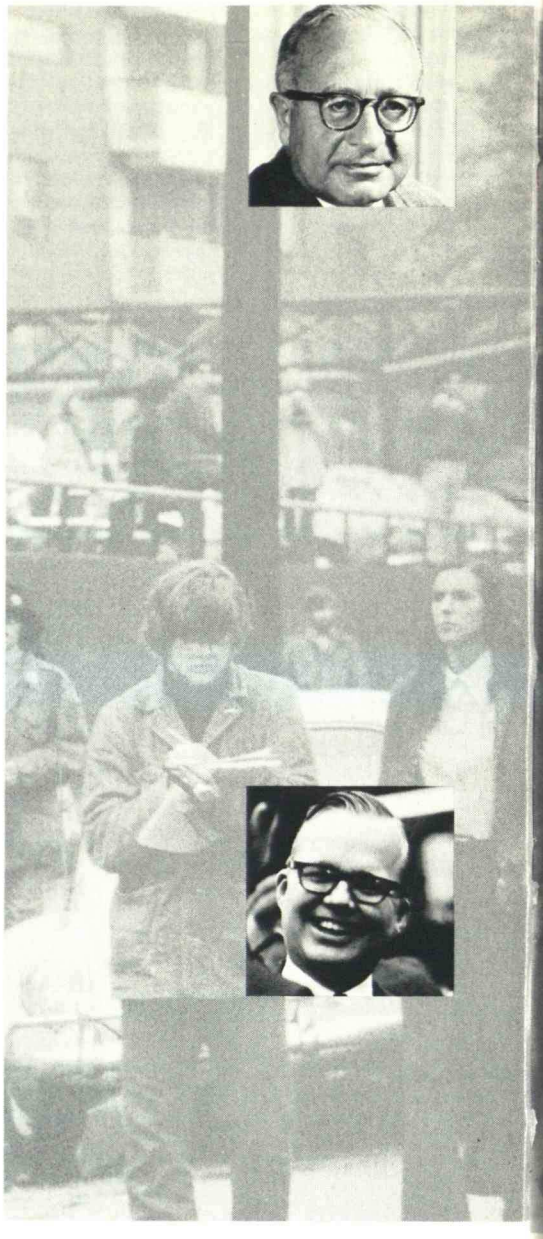
To acquire the best scientific opinion, Killian established within the White House a President's Scientific Advisory Committee (PSAC) served in turn by a series of expert panels. In this way, Killian provided the President with access, as needed, to the best minds in every scientific and engineering discipline. Eisenhower would later recall that, of all his advisers, he trusted them the most.

Killian quickly realized that many Americans attributed their country's apparent loss of world technological leadership to failures in the nation's schools. Curriculum reforms, funded primarily through the NSF, became an early Killian priority. The result was that by the middle of the next decade, major reforms in the elementary and secondary teaching of physics, chemistry, mathematics, and biology would begin reaching the nation's classrooms.

In higher education, science and engineering departments swelled with new recruits drawn by new federal and state scholarship and fellowship incentives.

Another important PSAC panel report would lead to the establishment of the National Aeronautics and Space Administration. The military services were working on their own rockets and all three were lobbying to develop space as an arena for military operations. Historians would mark the creation of the civilian space agency as one of the crowning White House achievements for Killian and his system of PSAC panels.

On March 4, 1969, several hundred members of the MIT and Cambridge communities attended a campus symposium on military research in academia. Topics ranged from "The Scientist in Military Affairs," to "Reconversion and Nonmilitary Research Opportunities." Like other college campuses, MIT was experiencing protests against the war in Vietnam. A sit-in was staged in President Howard Johnson's office, and an AWOL soldier was given temporary sanctuary in the Student Center. The early 1970s also saw the divestiture of the MIT Instrumentation Laboratory (now the Charles Stark Draper Laboratories), the establishment of the Union of Concerned Scientists, and a confirmation of the Institute's commitment, as a land grant institution, to ROTC training on campus.



Student demonstrators formed a backdrop for years in the 1960s and 70s that were otherwise marked by educational innovation and Nobel Prize-winning achievement.

(Clockwise from top left) Leading historian and philosopher of science Giorgio de Santillana taught at MIT for almost 30 years. Margaret MacVicar, '65, founding director of UROP. Biologist Salvador Luria. MIT team conducting underwater test of space construction methods. Economist Paul Samuelson. Professor of Biology and Chemistry, Har Gobind Khorana. Howard W. Johnson, president, 1966-71.

1955
At the suggestion of President Killian, the Committee on Educational Survey (called the Lewis Committee after its chairman, Warren K. Lewis, '05,) recommended strengthening the humanities and social sciences at MIT. A humanities major approved

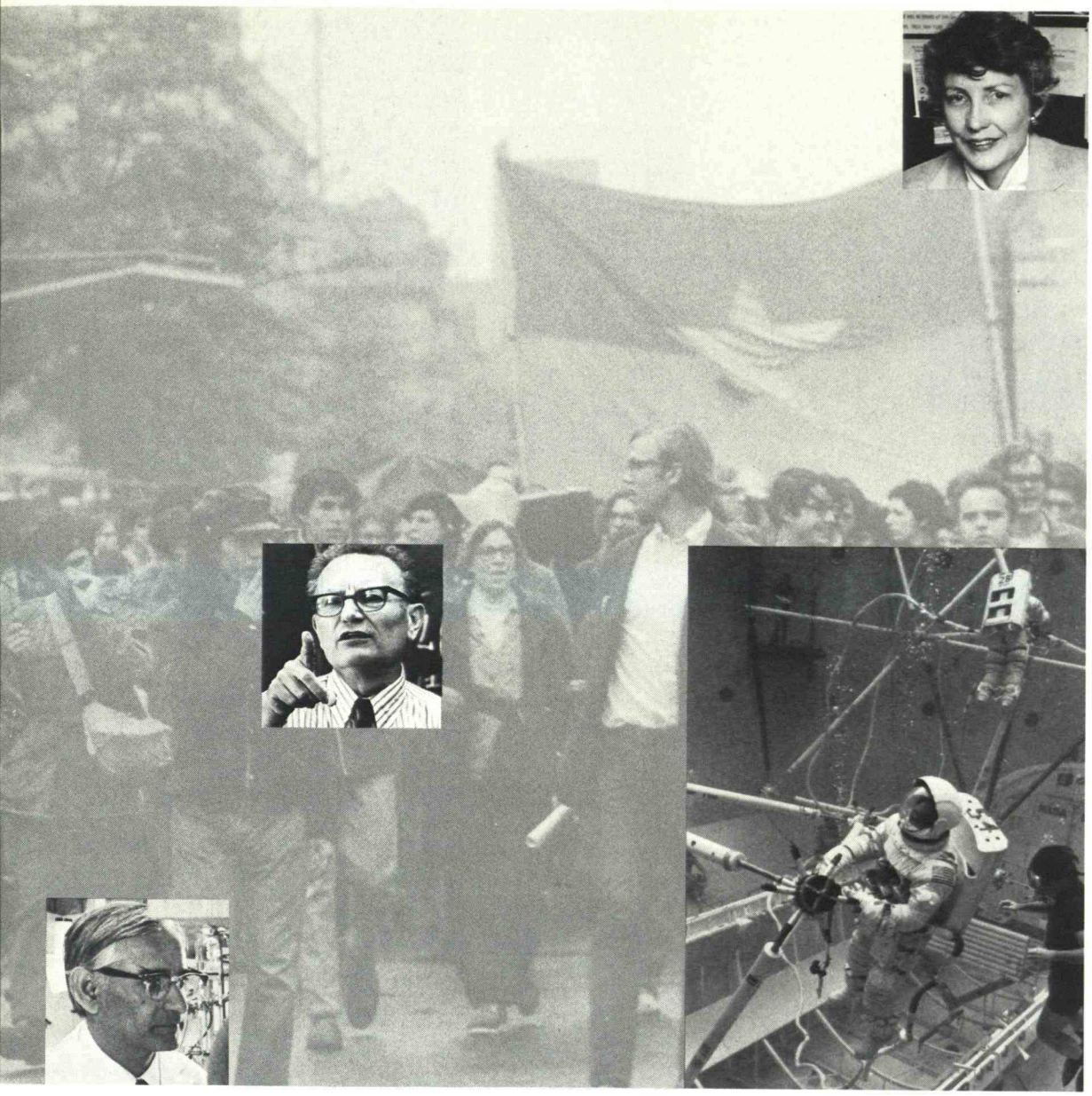
Sebastian S. Kresge Auditorium and Chapel, designed by Eero Saarinen, dedicated

1956
William Shockley '36 shares Nobel Prize for development of transistor; he is the first MIT alumnus to win Nobel

1959
Oliver Smoot '62 used to measure Harvard Bridge

Joint Center for Urban Studies established with Harvard

Julius A. Stratton '23 becomes 11th president



The Undergraduate Research Opportunities Program celebrated its first decade of operation in 1979. In 1969, then-Provost Paul E. Gray appointed Margaret L. A. MacVicar, '65, Department of Physics, to head the new program - the first of its kind at an American university. Dr. Gray had noted that an increased focus on research tended to alienate undergraduates. UROP was designed to draw undergraduate students into the research experience, grounded in project-based faculty-student collaboration. By 1984, the program involved large numbers of faculty and undergraduates as well as more than 150 industrial, health, and public service organizations.

1960
Second Century Fund campaign launched to raise $66 million; ultimately $98 million is raised for new buildings, endowed chairs, and research

National Magnet Laboratory formed under Francis Bitter

1961
MIT Centennial celebrated by week-long gala; speakers include Prime Minister Harold Macmillan of England, J. Robert Oppenheimer, and Aldous Huxley

Peace Corps created

1963
First tower of Stanley R. McCormick Hall, women's dormitory, completed; gift of Katharine Dexter McCormick '04

President Kennedy assassinated, November 22

1964
Charles H. Townes shares Nobel Prize for invention of laser

Departments of Psychology and Political Science are formed.

1965
New Student Center named in honor of Julius A. Stratton '23

Richard P. Feynmann '39 shares Nobel Prize for work in quantum electrodynamics

Robert B. Woodward '36 receives Nobel Prize for synthesizing quinine and other compounds

1966
Howard W. Johnson becomes twelfth president

Robert S. Muliken '17 awarded Nobel Prize in Chemistry

1968
Sophomores boycott Field Day, ending 64-year tradition

Pass/Fail grading introduced for freshmen

Har G. Khorana receives Nobel Prize for work with DNA

Martin Luther King, Jr. and Robert F. Kennedy assassinated

James D. Watson's *The Double Helix* published

1969
Project Interphase begins, as an element in the effort to encourage the enrollment of more minority students at MIT, providing an educational enrichment program in the summer preceding freshman year

Murray Gell-Mann '51 wins Nobel Prize in Physics

Salvador E. Luria shares Nobel Prize for discovery of mutations in viruses

1970
Offices of president and chairman occupied by 50 people

Joint Program in Health Sciences and Technology developed with Harvard

Paul A. Samuelson wins Nobel Prize in Economic Science

448 U.S. universities and colleges closed following Kent State slayings

At MIT in the decades that followed, one scientific achievement would fall hurriedly on the heels of another. Increased public funding in the information sciences would lead in the early 1960s at MIT to the beginnings of computer time sharing and artificial intelligence. Similar impact was experienced in materials science (ceramics and crystals), in theoretical and experimental nuclear physics (the BAG model of the nucleus, the theory of the inflationary universe, the discovery of the J particle), planetary and cosmic science (X-ray astronomy), in molecular biology (virology and genetic engineering), the neurosciences (chemistry and function of brain neurotransmitters), in mathematics (analytical number theory and related branches of analysis), and all across the broad spectrum of the engineering disciplines (from artificial skin for burn victims to models of regional electric power networks).

Scientific and technical advice has survived in the White House for nearly three decades. Of the nine who have served as presidential science advisers, three have been drawn from MIT–Killian who served Eisenhower, former President Jerome B. Wiesner who served Presidents Kennedy and Johnson, and Frank Press, who was head of the Department of Earth and Planetary Sciences when called to join the Carter Administration.

(Left to right) Frank Press, science advisor to President Jimmy Carter.

Laboratory investigations are a substantial element of the student experience.

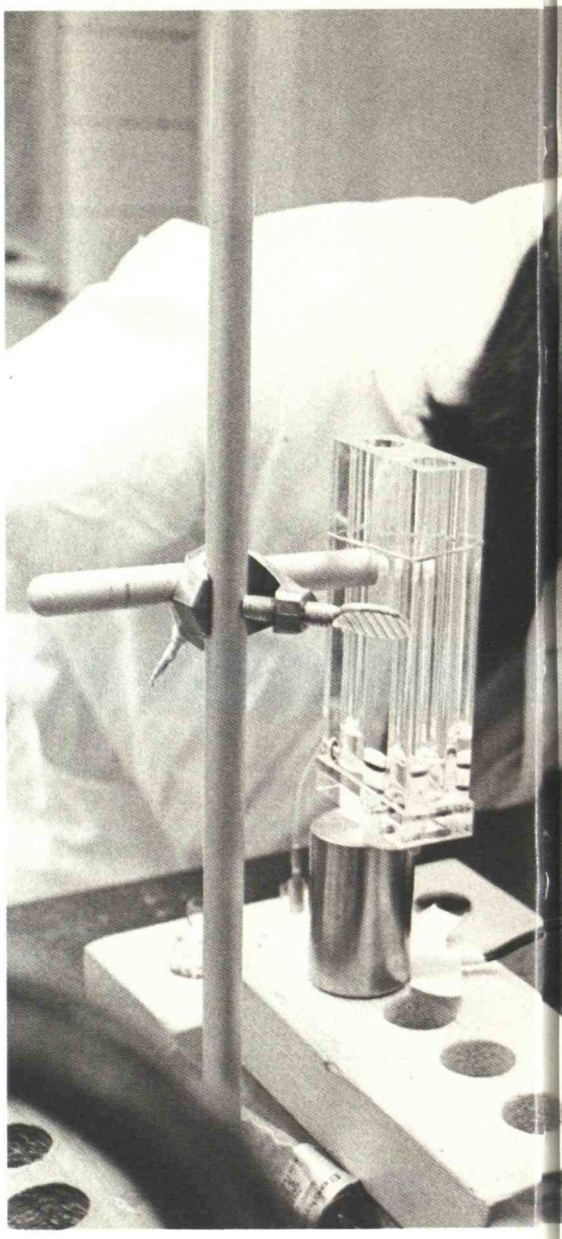
Biologist David Baltimore, '61.

(Top) Paul Gray, president since 1980.

Jerome Wiesner, president 1971-80.

Central artium of the Jerome and Laya Wiesner Building.

Economist Franco Modigliani.



1971
Independent Activities Period initiated

Jerome B. Wiesner inaugurated thirteenth president

Daniel Ellsberg leaks "Pentagon Papers"

American astronomers discover two "new" galaxies adjacent to Milky Way

1972
Energy Laboratory established

Carola B. Eisenberg named first woman dean for student affairs

Cambridge police tear-gas antiwar protesters on Massachusetts Avenue

1973
Center for Cancer Research established, headed by Salvador E. Luria

Whitaker College of Health Science, Technology, and Management established

1975
Chemical Engineering Building, designed by I.M. Pei '40, named in honor of Ralph Landau '41

Seeley G. Mudd Building, housing Center for Cancer Research, dedicated

David Baltimore '61 shares Nobel Prize for Medicine and Physiology

Surrender of South Vietnam ends Vietnam War

1976
Project MAC renamed Laboratory for Computer Science

MIT scientists led by Har G. Khorana complete synthesis of first man-made gene that is fully functional in a living cell

Samuel C. C. Ting wins Nobel Prize for "J" particle

1977
Frank Press becomes science adviser to Jimmy Carter

Center for Materials Research in Archaeology and Ethnology established

Alaskan pipeline opens

1978
Worst blizzard of century closes Institute for week

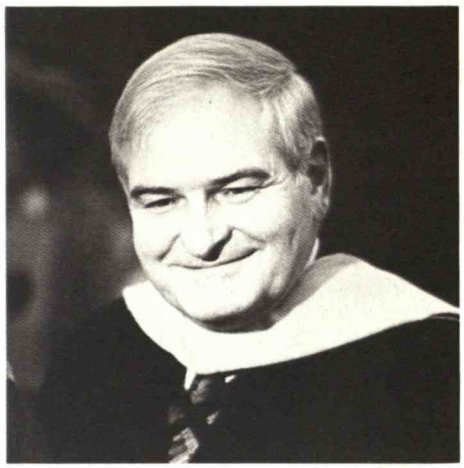
Henry G. Steinbrenner ('27) Stadium dedicated

1979
Sheila E. Windall '60 becomes first woman elected chair of MIT faculty

Tuition: $5,300

Aga Khan gives $11.5 million to endow Islamic architecture program at MIT and Harvard

Three Mile Island nuclear power plant malfunctions



The Wiesner Building for arts and media technology was dedicated in 1985. A unique collaboration between architect I.M. Pei and three artists, it houses the Media Lab and the List Visual Arts Center. The building was named in honor of President Emeritus Jerome Wiesner and Laya Wiesner, who have long championed communications research and the arts at MIT.

1980
MIT Leadership Campaign raises $250,232,000

Paul E. Gray '54 becomes fourteenth president of MIT

1981
Tuition raised from $6,500 to $7,400 per year

Iran frees 52 U.S. hostages after 444 days captivity in Teheran

First space shuttle, *Columbia*, launched

1982
Delta Kappa Epsilon plants weather balloon at 50-yard line of Harvard-Yale game; it inflates dramatically and bursts.

1984
29% of students admitted into the class of 1988 are women

Economist Anne F. Friedlaender, Ph.D. '64, appointed Dean of the School of Humanities and Social Sciences, the first woman academic dean.

1985
Professor Franco Modigliani wins Nobel Prize in economics for work on corporate finance

Dr. Eric Chivian, staff psychiatrist, shares Nobel Peace Prize with International Physicians for the Prevention of Nuclear War

1986: Where Do We Go From Here?

MIT was founded amid one of the earliest rounds of debate between what came to be known as the "two cultures." William Barton Rogers rejected such a division, believing that education should be both broad and useful, should embody both classical and scientific values.

Rogers' stance was echoed by his successors, none more consistently than James R. Killian, Jr., '26. "We need better linkages between science and the humanities," he wrote in his 1949 President's Report, "with the object of fusing the two into a broad humanism that rests upon both science and the liberal arts. . . . If we can achieve such intellectual integration, the basis for the conflict between general and specialized education will have been removed."

It was during Killian's administration that the School of Humanities and Social Sciences was established, and since that time MIT has made steady progress in the strength and scope of its programs in the liberal disciplines.

There is, nonetheless, a growing sense among MIT faculty that the Institute's programs are marked by an inadequate humanistic focus, overemphasis on professional training, and a lack of coherence in the nature of course offerings. If that strength of conviction exists across all departments it may well provide the needed impetus to develop the "integration" of which Killian spoke.

Now under scrutiny are the core Institute requirements in science and in the humanities, arts, and social sciences, and the entire undergraduate engineering program. Faculty are clarifying the goals of these programs and requirements, in terms of the world citizen MIT should be turning out for the 21st century, and then assessing where the curriculum serves these goals and where it falls short. New core subjects are envisioned that will integrate humanistic and technological perspectives. And discussions are in the early stages for a new liberal arts college and an integrated liberal arts degree that will both enrich the educational backgrounds of the liberal arts majors and leaven the entire undergraduate population with a more humanistic outlook.

It is clear that such new subjects and programs must be interdisciplinary—must encourage participants to see the interrelationships between science and technology on the one hand and social, political, and ethical forces on the other. The challenge of such an endeavor will be the education not only of the Institute's students, but also of a number of its faculty.

There is no master plan coming from the top administration down on precisely what such a new undergraduate curriculum could look like or on what strategies might be employed to implement it. Instead, faculty have been recruited in large numbers to serve on committees to wrestle with every aspect of the new curriculum. "Consensus," says Dean of Undergraduate Education Margaret L.A. MacVicar, "will come from the bottom up." What is being provided from the top, to an unprecedented degree, is the administrative structure and support to ensure that the changes recommended by the faculty are implemented.

Educational reform may sound like an internal matter, of concern to a few hundred academics in Cambridge. But in the hands of visionaries in MIT's history, curriculum change spearheaded new fields of study and new industries, prepared the country to win a war, and helped the U.S. to recover its technological confidence after the Russian satellite launches. It remains our leading hope for meeting our present challenges of international industrial competition, environmental threats, and inadequacies of food, shelter, health care, and economic opportunity for populations at home and abroad.

MIT 125 YEARS

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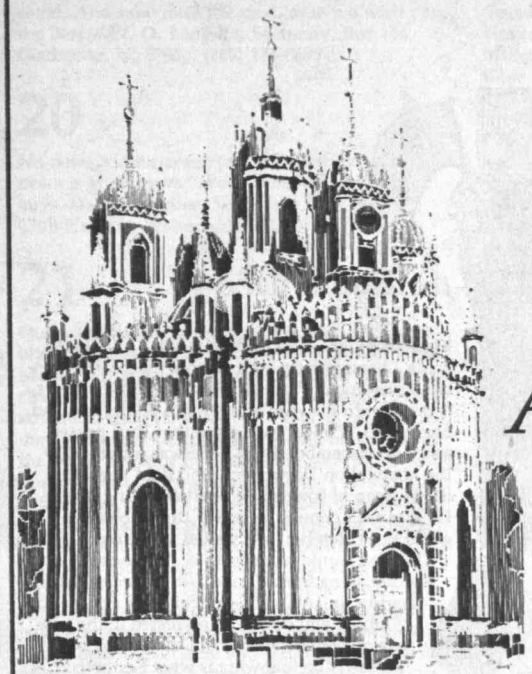

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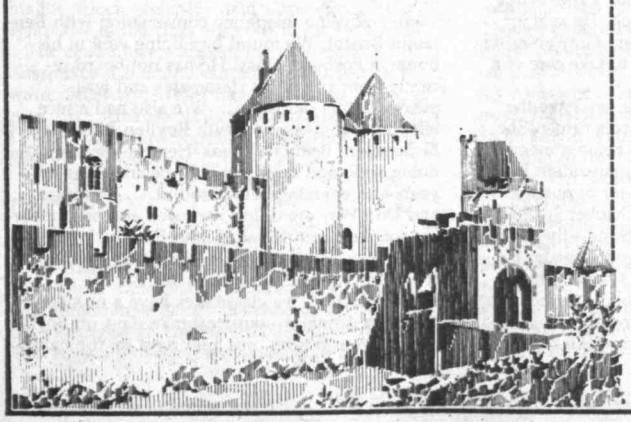

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16 70th Reunion

Our presentation of a letter from **John Fairfield** published in the January class notes gave the mistaken impression that **Dina Coleman** was keeping active with gardening, painting, and repair jobs around the house. For the record, it was John Fairfield who was doing these chores at his house. John, in a previous sentence had mentioned Dina along with Francis and **Paul Duff** as "always being good correspondents and pleasant company." Sorry for this misrepresentation, but it did lead to a very pleasant and encouraging telephone conversation with Dina in late January. Dina attended a wedding in August, as did John. Dina also mentioned that he recently fell and injured his head but happily reported that he had made good progress in his recovery and was beginning to get back into the swing of things. It's always a pleasure to hear from Dina. . . . Had a nice note from **Barney Gordon**'s son Gene in which he says, "My father is doing remarkably well physically."

Nathaniel Warshaw's son Stan writes about his father, who died on December 14, 1985: "He had 91 wonderful years with no sickness and no real problems, so we are all grateful for that." Nat retired as vice-president of the Barry Hyman Co. of Boston in 1974. Somehow we never were able to visit Nat while we were in Florida in recent years. He was a joy to know, and we'll surely miss him. He attended most of our reunions and was effective in getting others to attend also.

We received word that **Phillips N. Brooks** passed away in 1978. When we come together for our 70th reunion in June, we will remember in a moment of silence all our wonderful classmates who have gone before us. As this is being written, an effort is being made to get our classmates together at the luncheon on Technology Day, Friday, June 6. This could be something special for all of us. . . . Please write and let us know the special things that are happening as we move through our nineties.—**Bob O'Brien**, Acting Secretary, 28 Marinel Ave., No. Chelmsford, MA 01863

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I am indebted to classmate **Eli Berman**, presently sojourning in Florida, for this most interesting review of his activities—so typical of what M.I.T. men and women do so well. He writes, "For many years in partnership with my brother Leo, I operated a profitable business retail in radio and television. This was interrupted during the war years when I was employed with 700 other scientists, including Jerry Wiesner, at the Radiation Laboratory in back of M.I.T. About 25 years ago market conditions were against us, and we closed all six stores one by one. After that, I taught electronics, mathematics, and physics at Wentworth Institute and at Chamberlayne Junior College, alternating with assignments at nearby defense contractors like Raytheon and GTE. I am now happily retired and living with my wife in a luxury condominium in Brookline, Mass., and spending our winters in West Palm Beach, Fla.

"My two sons, George (1945) and Ralph (1946), are both M.I.T. graduates and are highly creative. George was a co-founder of Unitrode Corp., manufacturer of a miniature solid state rectifier. George is now chairman of a company with 3,000 employees that does a $200 million business worldwide .

"Ralph is settled in Montreal, Canada, with his wife and two sons. After leaving RCA, Ltd. of Canada, he constructed his first building on Sherbrooke St., Montreal, a ten-story office building. Since then, he has constructed many buildings across Canada and in Houston, Tex. At present, he is completing a 360,000-sq.-ft. office building near McGill University in Montreal."

Len Levine and **Herb Larner** sent Christmas correspondence. Len is in Florida—keeps busy with walking, bridge, and his men's club activities. Herb is his usual creative self. He sent a copy of his letter to President Paul Gray about his work after graduation—helping to take care of a smallpox epidemic in Alabama.

Thanks to his widow, Ida Mae, we have the following review of **John Kennard**'s career. She writes, "He thoroughly enjoyed being a member of the AT&T Bell Laboratories organization for 42 years. He became assistant director of outside plant development and retired October 2, 1962. His hobbies were golfing and fishing—fly-casting for trout and salmon in Maine and Canada. He was very interested in the solar system and the exploration of space and kept people in the libraries busy trying to find reading material."

We record the passing of Colonel **Alexander MacAlister, Jr.** —no further details. . . . Once again I have to note with sorrow the death of another classmate, **Paul McAllister**, with the news coming from his wife Margaret in Anderson, Ind. She writes,"I'm sorry to write that Paul passed away on December 4, 1985. He was admitted to the hospital on December 1 and died peacefully in his sleep of congestive heart and lung failure. He was well enough to take a trip to New England in September. We visited his sister in Etna, N.H. Paul would have been 88 on January 7. Before returning to Anderson, we visited our son, daughter-in-law, and grandchildren, ages 3 and 5.

"I think you might be interested in the tribute of a fellow worker at Delco Remy in Anderson. The following is what Kenneth McClure wrote, 'Over the years I have worked with a great many people. No one was more dedicated to his job than Paul. The ten years that we worked together was a continuous conversation that was most enjoyable. His excellent education, broad knowledge, and prolific reading made him an amazing source of interesting, useful, surprising, and sometimes almost unbelievable information. I am pleased and proud to have known him and count him as one of the very best friends of my lifetime.' I miss Paul very much and depended on him perhaps more than I should have."—**Max Seltzer**, Secretary, North Hill Apt. B-403, 865 Central Ave., Needham, MA 02192; **Leonard Levine**, Assistant Secretary, 519 Washington St., Apt. 15, Brookline, MA 02146

19

Hi! These class notes are being written during a New Jersey snowstorm. We hope you may read them during April or May in pleasant sunshine and with a happy summer before you.

Recently we received a copy of the M.I.T. Alumni Fund Annual Report 1985. Some of the statistics are printed in type a little small for us very senior citizens to read, but with some magnification we were quite proud of the figures for the class of 1919. For instance, 49 percent of our 55 living members made contributions that added up to a substantial figure for 1985. And, over the years, 1919 contributions to the Fund add up to a seven-digit figure. We thought you would like to know.

We enjoyed a telephone conversation with **Benjamin Bristol**. We found him doing well in his home in Foxboro, Mass. He has not heard recently from any of his classmates and was pleased to get our call. . . . We also had a nice telephone conversation with **Royden Burbank** at his home in Belmont, Mass. He and his wife are doing well, and he is proud to be crowding 90 years and enjoying being around. . . . Barbara and **Don Way** are doing very well and are preparing for their annual vacation in Florida. While there, they plan to visit **Gene Smoley**'s widow, who continues her interest in our class.

On reflection, we classmates have a number of things in common—our freshman days on Boylston Street in Boston, our later days on the banks

ILLUSTRATION: TECHNIQUE 1901

of the Charles River in Cambridge, and now our experiences with old age. So, do send us some words about you that we may keep our spot in the *Tech Review* alive. Your mates are really interested. And now until the next issue we wish you the best.—**W. O. Langille**, Secretary, Box 144, Gladstone, NJ 07934, (201) 234-0690

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No news, dear classmates. But, perhaps, "no news is good news." Your ever-hopeful secretary—**Harold Bugbee**, Secretary, 702 Country Club Heights, Woburn, MA 01801

21 65th Reunion

Our 65th reunion is almost here. This will probably be the last official reunion we will have. **Don Morse**, our reunion chairman, tells me that 16 classmates and five wives expect to attend. Seven additional men said "maybe," and 28 replied that they would not be coming. We will be staying at the Hyatt Regency in Cambridge, and M.I.T. will provide bus service to campus.

Carole A. "Cac" Clarke, our class president, writes, "Please tell our grand '21ers and '21ettes that we most sincerely request and urge them to share our 65th reunion events from Wednesday, June 4, 1986, through Saturday, June 7, at M.I.T. **Don Morse** and his capable reunion committee have arranged an extra-special program which will appeal to everyone and which will not be too exerting. If you have attended a 1921 reunion before, you know you will have an unusually good time, if you never have joined us on a 'track back to Tech' come see what you have been missing. We look forward to having you with us. In event you haven't had a formal invitation, please immediately write Eliza Dame, Room 10-115M, M.I.T. Alumni Association, 77 Massachusetts Avenue, Cambridge, MA 02139, for registration material or telephone her at (617) 253-8230."

Cac says that he sees **Munroe Hawes** occasionally, and Munny still goes down to his real estate office. Cac stayed home for Christmas, but he and Maxine are planning to take a trip in May from Ft. Lauderdale to Los Angeles via the Panama Canal. They will fly home from Los Angeles.

Bob Miller was planning a trip to the Holy Land this spring but, with all the violence in the Middle East, decided not to go. He will take a Caribbean cruise with one of his daughters.

I am indebted to **Harry Witherow** of Schenectady for sending me an obituary of **William R. Mathews**, of Spokane, Wash., who died on November 21, 1985. Harry, in turn, received the obituary from **Harold Cake**. **Bill Matthews** was the owner of Mathews Investment Co. and a founder of the Spokane Big Brothers organization. He attended Washington State University before coming to M.I.T. for his bachelor's and master's degrees. During his career, he worked for the Washington Water Power Co. and General Electric Co. and then established and operated Machinery & Tool Supply Co. throughout the Pacific Northwest. Bill designed the hydraulic mechanism for the Army Corps of Engineers for Columbia River lock gates. He held 17 patents. The sympathy of the class goes out to his survivors.

The class officers are hoping that more of our classmates will attend our 65th.—**Sumner Hayward**, Secretary, Wellspring House E64, Wash. Ave. Ext., Albany, NY, 11203 and **Samuel E. Lunden**, Assistant Secretary, 6205 Via Colinita, Rancho Palos Verdes, CA 90274

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If our classmates will pardon a look backward, I have found it interesting to note the number of undergraduate activities many of us survivors were engaged in. On the 1922 *Technique* were **Tom Alder**, photographic editor, and **Randall Spalding**, statistics editor; on *The Tech*: **Ab Johnson**, contributing editor, and **Werner Schoop**; *VooDoo*: **Walt Saunders**, circulation manager, **Tom Alder**, treasurer; **Bill Elmer**, art editor; and **John Strieder**, associate editor; in *The Beaver* were **Brod Haskell, Bob Prescott, Bunt Spaulding, Ted Miller** and **Bill Freeman**; Walker Club: **Mal McGhie** and **Brod Haskell**; Masque: **Parke Appel, Bill Gray, Brod Haskell, Fearing Pratt** and **John Strieder**; K_2S: **Tom Alder** and **Ted Miller**; Woop Garoo: **Tom Alder, Bill Elmer** and **Walt Saunders**; Baton: **Tom Alder, Lee Carroll** and **Yard Chittick**; Stylus: **Reg Hall** and **Frank Kurtz**; Technology Christian Association; **Ab Johnson**, president, **Yard Chittick**, director of freshman advisors, **Stanley Raffety**, director of church relations. Advise me of omissions for subsequent correction.

Bill Elmer is now in a new activity; this time as a substitute teacher in the physics class at Andover (MA) High School. His M.I.T. diploma met the required credentials. During the school sessions he was "surrounded by swarms of fine, handsome looking youths and unbelievably beautiful girls—all well-disciplined and respectful. The school was clearly extremely well run. I can't wait for the next call." Bill recalls that he was the "pretty girl" artist on *VooDoo* which should qualify him to say in referring to three very pretty girls who sat at his table at lunch: "The difference between looking at the best color pictures of beautiful women and looking at them in person is electrifying. It puts the photos right out of the running. Like George Bernard Shaw I can honestly say 'Oh to be 80 again'."

These notes have included in several past issues mention of the good work **Ray Burrus** has done and is doing in Hallandale, Fla., where he and Mrs. Burrus (Schotsy) have lived since his retirement. His activities are summed up in an appreciative article in the January 23, 1986 issue of the *Hallandale Digest*, the local newspaper, under the caption "City Editor Col. Burrus celebrates 87th Birthday." After briefly reviewing Ray's military activities in World War I and World War II, the account says: "After Burrus arrived in Hallandale, he immediately became involved with community programs and organizations. He has been a member of the Chamber of Commerce and is the only one ever to be honored to Lifetime Membership on its Board. Early in his Hallandale career, Burrus earned the title Dollar-a-year-man at City Hall. He was one of the founders of the American Association of Retired Persons. He is a member of the board of directors of the friends of the Hallandale Library and the Hallandale Historical Society. He is also a member of the Northwest Civic Association and the Southwest Improvement Association. Col. Burrus never says 'no' to a project he believes good for the area. Over the years, Burrus has kept a close eye on financial matters in the city. He has provided information regarding sewer and water matters which has been of value. He helped get traffic improvements through the Department of Transportation. He fought for better return on monies in the Police and Firemen's Pension Fund. He is one of the most intelligent, interesting and most controversial persons in Hallandale. He is an expert on all phases of municipal government and has made invaluable contributions to the City of Hallandale. The vast collection of statistics, charts, facts and references accumulated by Burrus around town are found weekly in the *Hallandale Digest*. He is our volunteer columnist and has been for 15 years. It all started as a favor to help out a reporter friend who had taken ill. Peter Bluesten, publisher of the *Hallandale Digest*, says of his columnist: 'Col. Burrus is an ideal illustration of useful, productive behavior on the part of a senior citizen.' Burrus attributes his long healthy life to one drink every afternoon, which he calls his 'Bourbon Renewal Program!' There is no question that Burrus' exuberance, vitality and excitement with life is a combination of good luck and iron discipline, but there is one more major ingredient—he is happily married."

When you read this, written in February just before Ruth and I left for Bermuda, it will be only 13 months to our 65th. Make all preparations.—**Yardley Chittick**, Secretary, Box 390, Ossipee, NH 03864

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John Silvasy reports that for pleasure he plays the oboe in three bands and does some fishing. . . . **Wilson Potter** died recently. He studied courses in general engineering with our class. He was employed by the New England Telephone Co. for 43 years until his retirement as an assistant chief engineer in 1966. In 1948 he was a major in the U.S. Army stationed at Fort Benning, Ga. He was a past president of the Appalachian Mountain Club, a member of the Old Huttman's Association, and he joined the National Ski Patrol System in 1939. An early enthusiast of motion picture techniques and an avid mountain climber, he often lectured to schools, church groups, and clubs on these subjects and about his experiences in the White Mountains and throughout the world. He was an active member of the United Church of Christ and of the Russell Lodge of Masons.—**Richard H. Frazier**, Secretary/Treasurer, 7 Summit Ave., Winchester, MA 01890

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Our co-secretary, **Dick Shea**, sends a note from Sun City, Fla. saying that he has no news from alligator country, except that he will go to San Diego on February 7 to board an American-Hawaii boat for touring the Islands for a few weeks to glimpse the hula dancers.

A note from **Paul Schreiber**: "We didn't go north last summer but made one short trip to Texas in August. In latter November we 'hung loose' for ten days cruising through Aloha land. Beautiful scenery and weather."

Roland Black writes: "Spent the spring, summer, and early fall in the hospital. Two heart attacks—one on April 8 and the second July 21. After a heart catheterization, I underwent surgery—a new aortic valve and four bypasses. Home only two weeks and then re-entered the hospital for prostate surgery. Home for ten days and back to the hospital where I spent my 83rd birthday recovering from reaction to medication. Now at home trying to regain my strength and some weight, having lost 50 pounds. Anticipate a cruise in late November and through December on the *Royal Odyssey* as she plies the waters of the Mediterranean and the Atlantic."

A note from Mrs. Kevan R. Jones, daughter of **Helen Gill Welling**, advises that Helen passed away September 25, 1985 after a short illness. Nothing is known of her career, but she was awarded a master's in chemistry. She summered in North Bennington, Vt. and wintered in Largo, Fla.

Ray Lehrer, putting up with cold weather in Sarasota Fla., is looking forward to returning to Massachusetts and Maine. He and Dorothy spent a three-week Christmas holiday in Toronto, Canada, where they attended the wedding of their granddaughter.

The Alumni Fund has received a special gift for the Guillemin Memorial Fund from Mrs. R.G. Meyerland, Jr., daughter of Professor Guillemin, in memory of her mother, who passed away in Wellesley Hills in November 1985. Professor Guillemin was internationally known for his work on communication network analysis and synthesis. He died April 6, 1970.—**Russ Ambach**, Secretary, 216 St. Paul St., Brookline, MA 02146; **Dick Shea**, Co-secretary, 7 Barkley St., So. Yarmouth, MA

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A letter from **Clarence Thulin** provides the sorrowful word that **Hollis Ware** died at Midland

Park, N.J. on December 28, 1985. Hollis was quite involved in class activities during the years that he was working in the Cambridge area with Lever Brothers. For several years in the late 1930s, he served as the class secretary. Hollis was one of the group of eight who received degrees in electro-chemical engineering (Course XIV), which along with mining engineering and petroleum production was closed in 1940. Clarence and **Rufus Palmer** are now left from the original eight.

Clarence pointed out that he lives about ten minutes from the Bangor, Maine, airport where Boston and New York planes sometimes get put down and suggests that if any classmates find themselves at the airport give him a call. Although Clarence prefers Bangor during the winter months, he spends considerable time during the summer months on Deer Isle, about 60 miles further south.

The Boston and Cape Cod papers carried the obituary of **Casper Ranger II**, who died January 20, 1986 at the Cape Cod Hospital. Cap was born in Holyoke and graduated from Phillips Academy in 1921 before entering the Institute. He owned Ranger Construction Co. of Holyoke until the mid-1930s and worked later for United Shoe until his retirement in 1968. He leaves his second wife, Marianita (Chalfin); a son, Joseph Ranger of Hong Kong; two daughters, Alice R. Mensel of Hooksett, N.H.; and Ann R. Bergstrom of Marblehead; ten grandchildren, and two great-grandchildren. —**F. Leroy (Doc) Foster**, Secretary, 434 Old Comers Rd., P.O. Box 331, North Chatham, MA 02650

26 60th Reunion

Even with the help of the Alumni Association and Marvin Pickett, who offered his services, the work on the class biography is moving along at a slower pace than we would wish. As we had anticipated, the information and opinions expressed are so interesting that there is a great temptation to stop work and merely read the material. More than 100 of our approximately 250 surviving classmates will be represented, a good showing as compared with previous classes.

As you may well imagine, the class of 1926 contributed more than its share to the tremendous list of major changes that have occurred in the world in the last 60 years. Looking forward to meeting as many of you as possible at our 60th. —**William Meehan**, Secretary, 191 Dorset Rd., Waban, MA 02168

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Next year at this time we will be gathering for our 60th (believe it or not) Reunion. The dates, set by your Committee headed by **Nat Cohn**, will be June 3rd to 6th, 1987. A good program is scheduled. Hyatt Regency and McCormick are saving rooms. Any Classmate who did not receive President **Bud Fisher**'s letter in January, let me know, because that was sent to all Class names and addresses of record. We don't want to miss anyone.

We haven't heard from **Theodore S. Bogardus** since 1969, until now. Having retired in 1971 from teaching engineering at Baldwin Wallace in Berea, Ohio, he continues to own a 2,000 acre Christmas Tree growing operation in Pennsylvania. He is also active developing his land property for residential and industrial sites as well as being involved in timber, gas and oil production. This sounds like a full-time job. Keep it up, Ted!

Herbert G. Johnson of Haverford, Pa., is still active consulting for his company Johnson Engineering Co. of Spring City, Pa. Herb has made an enviable record of accomplishments and helped put the U.S. forward in the world of metal processing. He has been granted many patents in the U.S. and foreign countries. Unfortunately his wife, Jeanette, is stricken with Alzheimers. Herb looks forward to coming to our 60th Reunion.

Cyrus A.W. Grierson died in September, 1985 in Whippany, N.J. He leaves his widow, Louise, and two children. He was born in Nova Scotia and after S.B. and S.M. in VI-A, he joined Bell Labs in 1928. He worked on dial systems and transferred to the toll system development department in 1936. He was associated with carrier systems and during World War II with various military projects. In 1954 Cy transferred to military communications systems development, where he was associated with the development of the transatlantic cable terminals. He was in 1958 a senior member of the Institute of Radio Engineers.

Arthur M. Hill died on December 17, 1985 in Pacifica, Calif. His widow, Helen, survives him. He was a graduate of Tulane University, New Orleans, and was a professor of mechanical engineering there in 1955. In 1967 they lived in Albuquerque and later retired to Pacifica. In early 1985 when I talked with Helen he had a sore joint in his knee, both hips were artificial, and he could not walk. She hardly had strength enough to get around to care for him, but they both did read and enjoy the *Review* and Class Notes. We extend our sympathy to the two widows. —**Joseph C. Burley**, Secretary, RFD #3, Epping, NH 03042; **Lawrence B. Grew**, Assistant Secretary, 21 Yowago Ave., Branford, CT 06405; **Prentiss I. Cole**, Assistant Secretary, 2150 Webster St., Palo Alto, CA 94301

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We are pleased to have a handwritten letter from **Ben Hough** addressed to **Jim Donovan**. Although the letter relates largely to a matter of class business, the firm hand and positive tone suggests that Ben is in very good shape. We truly hope that this is a correct surmise. Thanks also, Ben, for your kind words of commendation to '28 officers and their associates.

A letter from **George Palo** (also to Jim) contains mostly some preliminary thoughts on the 60th '28 reunion now just over the horizon. George's concerns relate to such matters as housing, food, and activites that will best suit the needs and interests of M.I.T. '28 super-octogenarians. We are delighted that such interest is already evident, and we welcome all of your comments and suggestions.

Florence and **Walter Smith** met with **Lazare Gelin** for lunch at the M.I.T. Faculty Club in late January. It was a pleasant occasion with all the fun of recalling past events and points of mutual experience. During his business years, Lazare held executive positions in electronic and avionic export companies. This work took him all over the world and made good use of his linguistic skills covering many languages. Now he pursues graduate-level studies at Hunter College in literature, history, and musicology—just for the interest of it.

We have a few notes that were forwarded to us from the alumni office. **George Chatfield** reminds us that he was editor of *The Tech* in his day. Now he writes editorials for his own newspaper, the *Montachusett Review*, a weekly that is delivered to 48,000 homes in north central Massachusetts and lower New Hampshire by his own carrier service. This service also distributes college catalogs and flyers for Sears, K-Mart, and 70 other clients. George is also vice-chairman for the U.S., Canada, and Bermuda of R.O.A.R. (Rotarians of Amateur Radio). Since 1969 he has served as "net control" of two weekly R.O.A.R. transatlantic voice nets. . . . **Dave Ingle** writes: "I thought retirement would bring me some leisure time. I can assure you that such is not the case. We are making a 1,000-square-foot addition to our house in the hope of finding some breathing room." . . . **Rene Simard** says: "Just living along. I helped to marry my 24-year-old youngest son on September 27. Planning our usual fall or winter trip to warmer climes."

Regretfully, we have this very tardy report on **Everett Vernon Lewis**, who died on November 29, 1982. The information was verified by his daughter, Nancy Jean Larkin. Following graduation in Course V (chemistry), Ev remained to earn his Ph.D. in chemistry. The earlier part of his professional life was in textile-related research. Later he became a professor of mathematics at University of Delaware, Newark, then at Ursinus College, Collegeville, Pa. Although belatedly, we extend our heartfelt sympathy to Ev's family.— **Walter J. Smith**, Secretary, 37 Dix St., Winchester, MA 01890

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Ernest K. Brown of San Clemente, Calif., writes, "We will be making a trip back to New Zealand where I was born and reared. I am working and training to become treasurer of my church." Ernest includes among his hobbies birdwatching, photography, golf, and hiking. The Browns have three children and six grandchildren. . . . **Butler King Couper** of Tryon, N.C. says, "On January 1, 1986, I became an octogenarian. I highly recommend "The Education of a College President," an autobiographical memoir by James R. Killian, Jr., '26, for some nostalgic references." For some time now Butler King's main hobby has been ham radio. He has his advanced class status, with call letters KA4A02. . . . **Al Moore** of Rockville, N.Y. writes, "Since I have no great events to report, I send greetings and wishes for a happy new year with good health to all my classmates. . . . I sent a note to **Putnam Cilley** of Sharon, Mass. inquiring about his friend, **Arthur Bearse'**, health and we have the following reply: "Arthur Bearse had an accident last winter 1985 and was in the hospital for some time. I saw him during the summer and he seemed fairly good but weak." Put and Art were good friends even before entering M.I.T. They always came to Technology Day together until last year when Arthur had to cancel for health reasons. Put has two children and two grandchildren and lists sailing, gardening, and woodcutting among his hobbies.

Mary, wife of **Frank Meed** of Marion, Mass. and North Port, Fla. writes, "We both want to thank you for the birthday greetings and the good news that you have received the Harold D. Lobdell Award for being our Class Secretary for 16 years. You most certainly deserve it. Frank well remembers that when he was urging you to accept the office, you thought you couldn't do it! Well, well, that is how things work out sometimes. At this writing, Frank is golfing which he does four times a week, and I am out there for nine holes on Ladies' Day. Last June and again in September Frank with friends from Marion (Kittanset Club) went salmon fishing in the Merrimack River. Frank hooked and landed a large one, but he was not allowed to keep it. It seems the anglers can keep only the little ones, which seems silly to me. Hurricane Gloria's high tide came up to our house in Marion, and we were all boarded up expecting the worst, but the tide changed just in time. We also experienced outskirt winds of Juan, and today it's Kate—very high winds. Frank accompanied me to my Lesley College 60th reunion last June, which will probably remain the climax of my involvement with my alma mater. Reading the 1929 class notes in the *Review* has become part of our cocktail hour conversations. Frank was shocked to realize that so many of our classmates have departed recently, the latest being **Warren W. Walker**, who was so devoted to M.I.T. and class of 1929." Frank's hobbies include gardening, golfing, fishing, birdwatching, and duck hunting. Professor **Herman (Fritz) Meissner** of Winchester, Mass., writes, "The "Salutation to Dawn" by Kalidasas in the class of 1929 birthday card is a beautiful poem. You rightly deserve to receive the Harold L. Lobdell Award for being our secretary for so many years. Unfortunately, we will not be able to attend the National Alumni Conference award luncheon to see you receive same. Our best wishes."

I regret to announce the death of **John H. Butler** of Columbus, Ohio, on December 16, 1985. His wife Dorothy wrote that he had struggled with a heart condition for several years and was finally unable to survive it. John attended Columbus Academy prior to entering M.I.T. He was a member of Lamb of God Lutheran Church, Central Ohio Chrysanthemum Society, and a past member of Ohio Society of Professional Engineers. He is survived by his wife Dorothy, a brother-in-law, Russell F. Madden, and several nephews and nieces.—**Karnig S. Dinjian**, Secretary, P. O. Box 83, Arlington, MA 02174

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As some of you may have noted, the December 17, 1985 issue of *Tech Talk* carried an article on a career development professorship recently established by a gift from Ruth and **Jack Latham** and their children. In announcing the gift President Paul Gray said: "M.I.T. is truly a family affair with the Lathams, and the Institute has been strengthened by their generosity and concern. . . . This new gift will support, now and in the years to come, many extraordinarily talented young faculty members as they work to expand our knowledge in these important fields." Dr. Monty Krieger, associate professor of molecular genetics in the department of biology and the Whitaker College of Health Sciences, Technology and Management, has been named the first Latham Family Career Development Professor. The article notes that Jack and his four children hold a total of eight M.I.T. degrees and describes in considerable detail Jack's impressive business and professional accomplishments, essentially all of which have been chronicled in the Class Notes of earlier years.

Ed Huson, who lives in North Arlington, Va., writes that the best news he can offer is that he and his wife of more than 50 years are "still alive and kicking." He retired in 1971 as special advisor in public utility finance in the Division of Corporate Regulation of Securities and Exchanges Commission, a job that he describes as "thoroughly challenging." The Husons have lived for more than 40 years in the same apartment unit, which has "no lawns to mow." . . . **Bill Locklin**, who lives in Guilderland, N.Y., retired as a project engineer for N.Y. Telephone Co. in the Albany, N.Y. area in 1969. His first wife died in 1979 and he re-married in 1981. The Locklins take a foreign trip each year and are active in church and masonic work.—**Gordon K. Lister**, Secretary, 294-B Heritage Village, Southbury, CT 06488

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A booklet sent to me by the Alumni Association reads as follows: "The naming of a major building for **Gorden S. Brown** [former head of the Department of Electrical Engineering and Computer Science and dean of the School of Engineering] is a way for this university and its people to express pepetual appreciation that he came our way, stayed so long, and did so much to make this place great in every positive sense—as student, teacher, scientist, engineer, and administrator. In an M.I.T. career that spanned more that four decades, he epitomized what this university has come to stand for—worldwide excellence, rigor, energy, imagination, leadership, service, achievement, dignity." (For more information on the dedication of the Brown Building, see *Technology Review*, February/March 1986, pp. A11-A13.) All of us are proud to have **Gorden Brown**, Institute Professor Emeritus, as a classmate, and he certainly deserves the congratulations of all of us.

It is with sadness that I report the death of two well-known classmates, namely, **George M. Bunker**, 77, a leading figure in the development of this nation's aerospace industry, and **August L. Hesselschwerdt, Jr.**, 75, who was a professor at M.I.T. and a Harvard lecturer. Our sincere sympathy to the families of these classmates.

Ruth and Abe Woolf, '28 celebrated their 50th wedding anniversary December 8, 1985.

Happier news also received from the Alumni Association comes from **Bill J. Hallahan**, who reports, "Officially retired from Fay, Spofford & Thorndike, Inc., December 31, 1984. Did a little consulting work during 1985. . . . **Henry Randall** says he is growing old slowly. . . . **G.T. Bevan** reports, "Busy as ever with yard, house, maintenance, and sailing and fishing on Seneca Lake. Had two grandsons from Texas visiting with us for six weeks this past summer. Expect to visit south Texas in February and March to avoid the cold weather here in New York state.—**Edwin S. Worden**, Secretary, P.O. Box 1421, Mount Dora, FL 32757; **Ben Steverman**, Assistant Secretary, 2 Pawtucket Rd., Plymouth, MA 02360; **John R. Swanton**, Assistant Secretary, 27 George St., Newton, MA 02158

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I must inform you of several of our classmates who have completed their journeys on this earth and have passed on. **Gardner H. Prescott** died October 18, 1985, after a long and complicated illness. Upon graduation, he lived and worked in Chambly, Canada. He succeeded his father as president of Bennett, Inc., a manufacturer of components for the shoe manufacturing industry. He is survived by his wife Helen, two sons, a daughter, and several grandchildren. . . . **Edwin B. Powell** died in his home on June 30, 1985, after a long illness. He served as a captain in World War II doing research and development in ordnance. He was vice-president of Blake & Johnson Co. He is survived by his wife Eleanor, a son and two grandchildren. . . . **Kirk Horigian** died on November 11, 1985. He started to work at the age of five delivering groceries with a horse and cart. He eventually earned enough money to attend M.I.T. He went to Detroit and in a few years started his own business. His daughter Elaine said, "He always strove for excellence." He was active in many business organizations, social clubs, and in the local Armenian community. He is survived by his wife Mary, his daughter, and two step-grandchildren.

Rufus K. Dryer died on December 23, 1985. For many years he was deeply involved with the Rochester Psychiatric Center, serving as President for many years. He was active in architectural circles, banking institutions, and civil and social clubs in Rochester, N.Y. . . . On November 22, 1985 **George Kerisher** died peacefully at his home. George had a mild stroke about two years ago. His son took good care of him during this period. George was our class treasurer for many years and was deeply interested in M.I.T. After graduating from M.I.T., he worked for several years with a major valve manufacturing company and then started his own company, G. K. Kerisher Co. He was active in many civil and professional clubs. He is survived by his son.

Don Brookfield has recovered from a minor operation. His family has recently celebrated his youngest son's 40th birthday. By the time these notes are printed, we will be about a year away from our 55th reunion. Don, our class president, would like anyone who would like to participate in the planning to please volunteer. The more on the committee, the better the reunion will be. . . . **Bernard Markstein** is taking life easier. He spends some time at Lake Placid. His hobbies are photography, tennis, and six grandchildren. . . . **William Bannon** is enjoying his retirement. He and his wife Eleanor take many trips. Their son, daughter, and three grandchildren keep life interesting.

Pick up a pen and drop us a line. We want to hear from you.—**Melvin Castleman**, Secretary, 163 Beach Bluff Ave., Swampscott, MA 01907

33

Here it is spring again, even in New England, and Alumni Day is in the offing—if you are a regular, keep up your attendance. If you haven't attended in a number of years, come back this year. If you have never been to M.I.T. for Alumni Day, come try it this year and see who attends from our class.

There is a little note from **Lenox Lindsay**, all the way from Laramie, Wyo., saying that he moved west in 1972 and has been active in the national ski patrol for 40 years and only retired from active participation in 1983. He remains a downhill skier and an avid fly fisherman and golfer. Last year he became a great-grandfather. For the first time, Lenox? He has attended every 10th-year reunion and is planning to be with us in 1986. If you would like to write to him, address it care of the Whittons, and we will see it gets forwarded to him.

Warren S. Daniels, one of our civil engineers has had two nice trips: to Japan in January and to Sri Lanka later in the year. He also had a son's wedding in August 1985.

There was a three-line report from **Frank Vanucci** of Newark, Ohio, saying that he had enjoyed all nine years of his retirement after 42 years with Owens Corning Fiberglass Corp. How do you spend your time, Frank? He was one of our mechanical engineers.

Bob Dillon writes to ask the address of **Fred Kressman** who passed away some months ago. He will write to widow Loretta.

The Dillons (Bob and Alice) celebrated their 45th wedding anniversary last year. He says La Marque may not be the hottest place in Texas, but it seems too warm for classmates to come visiting. By now they have probably taken that promised trip to Rio and Brasilia on their favorite cruise ship, the *Vistafjord* to get a good view of the comet from down south where the view is the clearest. Bob says he was born a year too late to see Halleys last time. He has received all kinds of advice regarding the proper exposure, and kind of film . . . sounds like it will be a good experience. He is now national vice-president of Carbide retiree service corps.

Via **W.J. Henderson** there came a picture of Louise and **Ellery Clark** with a glacier in the background made on their cruise to Alaska last summer. They are both smiling and bearing out Ellery's earlier report that it was a pleasant vacation. In addition to cruises, the Clarks made a number of trips in their Airstream trailer.

Did we report that **Warren Henderson** now

lives in a rest home in Boca Raton, Fla.? Some of you regular correspondents may want to drop him a note at 23305 Blue Water Circle, Boca Raton, FL 33433.

When you see a familiar name in these notes, drop him a note care of me, and I'll see what we can do about getting you a reply.

All goes well in North Carolina. Daphne and I hope it is the same for all of you.—**Beaumont Whitton**, Secretary, Cottage 112, Sharon Towers, 5150 Sharon Rd., Charlotte, NC 28210

34

My thanks to **George Bull** for filling in while I was away jaunting; at the moment I don't expect to do quite so much this year, but I can dream.

Let me start with our latest losses, unfortunately this now seems to be a constant source of items. **Betsy (Kelley) Weeks** died on February 13, 1985. She has been married to William Weeks, '31, and they lived in Fort Smith, Arkansas.

On December 6, 1985 **Constant Chase** died in Seminole, Fla. Connie, as you may recall, had spent most of his working career in Panama, working on the Canal. His wife had died a few years ago but I don't know whether they had any children. In neither of the above instances do I have any more information.

On October 24, 1985 **Charles Jerome** passed away in Marblehead. As far as I know, he spent his career in the illumination field and had retired from the Sylvania Lamp Div. of GTE Corp. as a manager in 1976. During World War II he had served as a lieutenant colonel in the army. Chuck had a major interest in sailing; he was a member of the Corinthian Yacht Club of Marblehead and had won many sailing trophies. He was also active in the U.S. Power Squadron, was a past commander, and at the time of his death, current secretary of his local squadron. He is survived by his widow Constance, a brother, two daughters, and both grandchildren and great grandchildren.

To the families of these members of our class who we have lost, I would offer condolences on behalf of all of us.

On the pleasanter side, there are a couple of Alumni Fund notes. **Jerry Raphael** can't keep his hands away from concrete and writes: "By now our class is getting used to 50th anniversaries but I just came back from the 50th birthday of the Hoover Dam, where I presented a paper 'Hoover Dam plus 50 years equals El Cajon Dam.' I worked on both dams and it was fun comparing two arch dams built on almost identical damsites and 50 years apart. El Cajon is now completed in Honduras—one fourth the thickness of Hoover. Quite an achievement: new analyses, stronger concrete, better understanding about earthquakes, and, of course, computers in design and construction."

In another note, **Gil Lorenz** shows he's been getting his money's worth out of Eastern Airlines. He says, "We continued our travels this year, making ten trips in our Eastern senior passport. We extended our trip to Montreal to go to a fabulous 60 year wedding anniversary for a couple in our condominium. We attended the reunion in Williamsburg and then spent three weeks in Northern Italy. Our daughter Julie and family are moving to Concord, Mass., in January, so I have more reason to come to the Boston area."

I've written several times about the varied activities of Father **Joseph Hahn**—traveller and photographer, book publisher for the Maryknoll order, and top-flight bridge player. A clipping from the *New York Times* of December 4, 1985 brings a column by their bridge expert, Alan Truscott on a coup by Joe. It outlined a hand on which he was the only one of 18 in a duplicate game to bid and bring home a tricky grand slam in no trump! If you follow the game at all, even from a distance, you know that most of Truscott's comments are about major tournaments.

A final item: I have a note from **Larry Stein**, our treasurer, that he has one extra copy of the 50th reunion class photo. As treasurer, he'd rather have the cash than the copy so the first check for $15 he receives at 374 East St., Hingham, MA 02043 can have it. It's a really good picture as all of us who were there know.

This is written in the middle of February when the Cape has almost more snow than Boston. In about three weeks I'll be off for a trip to Florida and another visit to the Everglades.—**Robert M. Franklin**, Secretary, P.O. Box 1147 (620 Satucket Rd.), Brewster, MA 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Apt. 711, Chevy Chase, MD 20815

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A reminder to let you know that a VHS videotape of our 50th and some of the 45th is available for you to borrow simply for the cost of postage through the efforts of **Ed Taubman**.

Art Haskins' Christmas letter starts and ends with boating and has a lot to do with the same subject through the middle. The info about son Dan is that he is still head of the mechanical engineering department at Franklin Institute. Dan had two months off last summer part of which he spent running racing ragattas. He does all his own automotive work and is a handy man to have around the docks. Daughter Carol and husband Wayne came East from Colorado in August. Carol teaches combined 4th and 5th grades in Nederland, part of the Boulder School District. Wayne commutes to Denver for his engineering work. Dot keeps the family fed at Bath as well as "the biggest and most diversified flock of birds we have ever had." Dot does the job of keeping in touch with friends and family all year leaving the "one rare contribution yearly" of the Christmas letter to Arthur.

Phyllis and **Charles Debes** are currently basking in sunny Key West. Last Fall they spent 5 weeks travelling in and around Singapore where daughter Cheryl is bureau chief of *Business Week* Bureau which she was sent to develop from scratch in 1984. They returned to have Thanksgiving dinner with Mary Brent and Jim. Robin and Kim live in St. Louis Park, a Minneapolis suburb with their 8-month old daughter. Kim is now with In-Tel as a software specialist. Phyllis added a nice postscript: "Thank you for the wonderful reunion—there is no better class anywhere! All of your work was appreciated and more than enjoyed. We're still basking in happy memories."

Natalie and **Sam Brown** are in Punta Gorda, Fla., at this point, which is really a wild assumption on my part because they are two very busy people. Sam went to New York over 15 times last year with nearly 40,000 miles air travel. Last Fall however they both got away with Natalie's brother and wife for a fine trip through Austria and Germany, driving their new Renault R-18 GTL they picked up in Paris. Sam's daughter Joan Winston lives in Springield, Ga., with two daughters Sarah and Christine ages six and seven.

I report the death of two of our classmates, one of whom, **Edward C. Edgar**, attended our 50th. Ed died January 28, 1986 in Leesport, Pa., his home for a number of years. He was associated with Gilbert Assoc. since 1946 and retired as president of Gilbert Management Consultants. He was an amateur archaeologist and participated in several Mexican expeditions. He leaves Marjorie, his widow and a daughter, Alison Shimer. **Theodore A. Earl** died June 22, 1985 at Winter Harbor, Maine, and I am sorry I can not add anything to that notice. I am sending our condolences to the families.—**Allan Q. Mowatt**, Secretary, P.O. Box 524, Waltham, MA 02254

36 50th Reunion

By the time you read this, our 50th reunion will be upon us. The time between my writing and the publishing of these notes is so extended that there is little that can be said except that if you find at the last minute you can participate in some or all of the reunion events, do not hesitate to make inquiries. From the opening dinner on June 4 through the closing lunch at Chatham Bars on June 8, you will be welcome!

Edwin A. Boyan died suddenly on December 8, 1985. He is survived by his widow, Marilynn, who resides at 3600 Prospect Ave., Riverside, CA 92501.

As a result of class mailings, I have learned of the death of a graduate member of the class. **Laxton M. Smith** died on December 15, 1985 in Venice, Fla., whence he had migrated after retiring from DuPont.—**Alice K. Kimball**, Secretary, P.O. Box 31, West Hartland, CT 06091

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This was a difficult year for your assistant secretary, because of illness. After 1984 Thanksgiving dinner, we learned my daughter Marty had lymphoma cancer. After chemotherapy and radiation treatments, Marty feels better. She felt well enough to make a business trip to San Antonio, Tex., to attend a non-commissioned officer association job fair, for her employer MA/COM. She lives in Peabody and continues to love her work as a personnel recruiter. Don D'Entremont, Martha's husband, is a designer for AVCO. Robert, 22, graduated from Brandeis, is temporarily working for a mosquito control project, and in summer and fall sailed with grandpa once a week. Michele is a sophomore at University of Vermont, and worked in a bank last summer. Mark is in ninth grade and spent last summer at the Explorer's program at Wellesley College.

I entered Mass. General Hospital in January for a prostate operation and Pearl entered in May for heart surgery to replace an aortic valve and free

up her mitral valve. Pearl's daughter Sue is a partner with Harbridge House, a business consulting firm, and daughter Emily is a preschool teacher. Robert Pearlstein, Emily's husband is a research biologist with the children's neurological research laboratory at Children's Hospital, Boston. He is also involved with the medical use of computers. Emily's two children, James, 6, and Sarah, 11, are a joy to the only grandfather they ever knew. Pearl and I are enjoying our five grandchildren at all their different ages. I continue to be busy as a trustee of our condominium association and both of us are happy living in our condominium.

Eric O. Moorehead (223 Avenda Barbera, Sonoma, CA 95476) retired December, 1980 as a self-employed structural engineer. Gardening is Eric's hobby. His travels have been cruises to the Caribbean, Alaska, Scandinavia, Finland, Russia, and the Panama Canal. Wife Jessie's main interests are gardening, golf, bridge, and aerobics. Eric writes that it's "great being retired. Wonder when I had time to work."

Col. **Joseph A. Smedile** (3579 Admirals Way, Delray Beach, FL 33444) writes: "This is our fifth year in Florida. Initially, there were 42 homes built here out of 207 proposed. For the past four years there was no new construction. A third developer has now taken over, and with three other contractors there is now much activity. Eight new units were completed recently, and a large number of others are under way. We have suffered the usual pains of living in an active construction site—noise, dust, loud radios, nails in tires, lost hub caps, and perforated mufflers from driving over rough roads.

"Our most important news of the year was the arrival of Catherine Martha Smedile in Kansas City, Mo., on May 20. She joined her brothers Tommy, 5, and Jack, 2. What a joy to see them all: happy vibrant children and proud parents, Pam and Gary. Pam and Gary are still with TWA. After several takeover and buy-out attempts, the company was sold to one Carl Icahn. Personnel and pay cut-backs are scheduled.

"After five years of patching the roof over the first floor wing and mopping up our master bedroom after each heavy rain, complete re-roofing was scheduled for late October. We thus decided to leave the house for a scheduled 10-day period. So, we took an AMTRAK trip to Montreal, with stops in New York City, Washington and Williamsburg, Va. We thoroughly enjoyed seeing the fall foliage, our visits with friends, a play in New York City (*Cats*), and the colonial charm of Williamsburg. When we returned on October 30, the roof repairs had not been made! Because of the rainy season, work was postponed until mid-December. At that time they plan to replace the entire roof and improve the drainage. Would you believe that in the standing water on our roof we had zillions of polywogs swimming around? Yes, our roof was used by local frogs for their amorous adventures! We have enjoyed good health most of the time. In mid-November Martha came down with a very painful and swollen left foot (her good one), which bedded her. On December 14th the results came back: gout! The doctors all agreed they had never seen such symptoms of gout. Under new medication, she is now making progress, determined that she will be able to wear a shoe on her left foot by the time we leave for Kansas City."

Duane O. Wood (920 Linda Flora Dr., Los Angeles, CA 90049) retired in 1979 as executive vice-president of Triad Holding Corp., and is now semi-retired and president of CCIT Corp., his own consulting firm. Non-work activities are hi-fi and video equipment, charity organizations, and skiing. Travels are mainly business travels to Asia, Middle East, Europe (ten trips last year). Wife Beverly is deceased. Jayne Conners, Cathy Nardlund are daughters and Shannon Conners is granddaughter. Duane writes, "Although it has been nine years since I retired as president of Lockheed California Co., I have been as busy as ever doing consulting work for a number of U.S. and foreign firms. I am fortunate to have my family living in the L.A. area, so have an active social life as well."—**Lester M. Klashman**, Secretary, 289 Elm St., Apt. 71, Medford, MA 02155

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Dick Muther is one of us who just won't retire. He now has a new business, Arundel Enterprises Inc., which develops aids for advancing individuals and managements. Dick still runs seminars under the sponsorship of the National Society of Professional Engineers. Subject: "Creating Success." . . . **Bernard Brod** is in the wood millwork business as a sales rep for some of the leading manufacturers. . . . **Welcome Bender** retired from Custom Engineering, Inc. in 1984, moved to Santa Barbara, and is now program manager with the Center for Robotics Systems in Microelectronics at the University of California, Santa Barbara. . . . **Russ Coile** is chief scientist for Planning Research Corp., which is providing a scientific support group to work at the U.S. Army's Combat Developments Experimentation Center at Fort Ord. Russ extends a cordial invitation to all '38ers to stop by and visit him in Pacific Grove. . . . **Lew Allen** says he's going to make the next reunion. . . . How about you?

Traveller **Don Severance** recently saw **Howard Lawrence** in Cherry Hill, N.J. Howard is owner and operator of Browns Mill Shopping Center, this after retiring from RCA and subsequently from a small company that he and another chap started and eventually sold.

I fear that our globe-trotter and 50th class gift chairman, **Ed Hadley**, should slow down. Last year he got Kenya and the Balkans out of his system. Then he was off to Israel for a three-week Elderhostel study tour. Lo and behold Barbara and **Les Kornblith** were on the same plane. Ed then made it over to Italy for several weeks. There may be a moral here, because this February he wound up for four days in an intensive care unit with his own supply of heart medicine and nitroglycerine. As Ed puts it, Jean may have to find someone else to go to Tibet with her.

Two deaths to report—**George Stansfield** of Alexandria, Va. passed away last October, and **Harold Rosenthal**, who lived in Belmont and Boynton Beach, died last December. Harold is survived by his wife Amy.—**A.L. Bruneau, Jr.**, Secretary, 663 Riverview Dr., Chatham, MA 02633

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Professor **Richard Feynman** authored a book entitled, *QED: The Strange Theory of Light and Matter*. Dick is famous for his work in theoretical physics and is especially known for his ability to interest and inform non-technical listeners attending his lectures about modern-day physics. . . . **Martin Lindenberg** retired from his manufacturing business in North Dartmouth and now teaches electronics. . . . **Melvin Falkof** retired after 25 years of directing the purchasing and operations of supermarket store equipment. Four children and nine grandchildren provide activities for Mel and Lucille in retirement.

Jim Barton paused long enough from his duties as mayor of Hunts Point to observe, "Life in the slow lane is plenty fast." Then, responding to our comment that this fits all our classmates in retirement, Jim continued, "Also, they don't make time like they used to." When we heard from Jim, his political duties that day were concentrated on preparing for a town meeting for 500 constituents. Mary was away doing her three-times-per-week tennis.—**Hal Seykota**, Secretary, 1415 Seacliff Dr., N.W., Gig Harbor, WA 98335

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Joe Greenberg writes from Chicago that he is still working as an independent consulting engineer specializing in the metallurgical and metalworking industries. He has just recently completed an engagement in Egypt and has one pending in China.

The National Executive Service Corps., a non-profit management consulting organization dedicated to improving the effectiveness of other organizations in the voluntary section, recently cited **Peter M. Rinaldo** in recognition of his outstanding volunteer services to Booth Memorial Medical Center in Flushing, N.Y. and the Montefiore Medical Center in the Bronx. Peter is a retired vice-president, General Industrial Products Group, W.R. Grace and Company. Frank Pace, chairman of National Executive Service Corps., presented him with a silver tray and a silver frame.

A short note from **Abe Rockwood** of Needham, Mass. indicates that, although retired for five years, he is growing and showing gladiolus throughout New England. Traveling overseas and in the states had made life very pleasant for both his wife, Jean, and him.

Although your secretary has been hospitalized and ill for the past several weeks, with firm faith he intends to overcome this problem.—**Donald R. Erb**, 10 Sherbrooke Dr., Dover, MA 02030, (617) 785-0540

41 45th Reunion

Stanley Jarrow, my neighbor in Chicago and good friend and advisor writes: "I am president of Jarrow Products, Inc. We are in the plastics extrusion business with plants in Chicago and St. Charles, Ill. My wife Elinor and I live in Chicago and spend a month or so every winter in the Florida Keys. My main summer recreation is boating on Lake Michigan and in the winter fishing in the Florida Keys. I am on the board of trustees of Michael Reese Hospital and am a director of the Midwest Industrial Management Association. We have one daughter and two granddaughters." It is great hearing from you, Stan, and many thanks for all your past kindnesses.

One of the sad by-products of reunion planning is to find who in our class has died: **Edgar F. Smith**, September 4, 1981. **Edmund F. Dandrow** died on September 15, 1985. **Robert Arthur Mallory** died on November 25, 1985. Robert was a member of the Mass. State Board of Education in Somerville. He was a native of Philadelphia, Pa. and lived in Palmyra before moving to Branchburg 36 years ago. He had been a research chemist at Ortho Pharmaceutical Corp. in Raritan borough for the past 41 years. After graduating from M.I.T., he earned a masters degree from New York University. He was a member of the First United Church of Somerville and a member of the church choir. He is survived by his wife, Namoi Swayne Mallory and by four daughters.

The winter issue of *The Corporation Development Committee* printed an interview with **Carl M. Mueller**. From it we learn that Carl has been named Chairman of M.I.T.'s Corporation Campaign Committee and is actively involved with M.I.T.'s senior officers in planning the upcoming capital Campaign. A graduate in mechanical engineering, Carl began a career with Bankers Trust Co., after serving in World War II. After 15 years with Bankers Trust, he joined the investment banking firm of Loeb and Rhodes, where in due course, he became managing partner. When the firm was incorporated, he was named president. In 1977 he returned to Bankers Trust as vice-chairman, a position he held until his retirement in June 1985. The interview is fascinating but too lengthy for Class notes. Carl first visited M.I.T. when he was 12 and from that day on it's been a love affair. He's been motivated by the feeling that those who have had a little fortune in life should plow some back, both in resources and in effort. The Class of '41 salutes **Carl M. Mueller** for his great contribution to the Institute.—**Joseph E. Dietzgen**, Secretary, Box 790, Cotuit, MA 02635

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Good news this month! Retirements out-number obits two to zero! **Heinie Shaw** retired two years ago but just sent the news recently. He has been back to TRW consulting for about three or four months. Otherwise he works three days a week at Marineland conducting tours, doing some design and computer work and helping with animal handling which includes swimming with the porpoises! The Shaws still ski - some 49 days of it last year and have traveled to New Zealand, China, Japan, Alaska and to the Galapagos Islands. Also Heinie has done "Bare Boat" cruising in the British Virgin Islands, the Sea of Cortez and off British Columbia. My mind being what it is, would sure appreciate it if Heinie would write and let me know whether "Bare Boat" cruising has anything in common with "Nude Beaches."

George Toumanoff has retired from a very fancy position: vice president of the international business department of government systems operations of Eaton Corporation. George wins first prize for impressive titles. He is still sailing, horseback riding, playing some tennis and has just renewed his private pilot's license. To keep out of trouble, George got elected a Village Trustee, is a director of the Huntingdon Arts Council, an adjunct faculty member at Friend's World College, a member of the International Measurement Confederation (which meets in Budapest) and is still an M.I.T. Educational Counsellor.

Carl Zeitz, still working at peddling packaging materials, sadly reports that his golf handicap which was once 7 has rocketed up to 18. (Wish mine was that low!) He reports two grandchildren, five and two years old. Carl's son Barney, is living on the Cape and creates stained glass windows so if any of you yearn for stained glass in your retirement homes, call Carl. . . . Zelda and **Bernie Levere** are still travelling; currently through Africa in Botswana, Zaire, and Kenya followed by a North Cape cruise, "for a change of scenery." Their son, David recently married Amy Tenney a niece of Jim Berman, '49, thus keeping it in the M.I.T. family.

A short note from **Charlie Stempf** from "Down Under." Charlie will be in the States at an anniversary celebration of his World War II ship, the *USS Drum*. He writes that "only divine intervention could keep him away." There will be a mini-reunion at **Hawk Shaw**'s place in Ipswich, N.H. The festivities (the word "fracas" seems to come to mind), will be extensively reported, if there are any survivors—including your Secretary—in the next issue.

Bit of puffery for the record: I was just elected a vice president of the Jewish National Fund, an organization which raises funds for Israel by selling trees at $10 each. When I was a kid, the price, if memory serves, was 25-cents per.

Anyway, we raise about 35 or 40 million dollars a year, and that's a lot of wood!—**Ken Rosett**, Secretary, 191 Albemarle Rd., White Plains, NY

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Antonio Badia reports that, after 30 years with the Exxon organization, he has retired from Esso Standard Oil Co. (P.R.). . . . U.S. Navy, retired, Rear Admiral **Richard E. Henning**, writes, "Jean and I are enjoying my retirement-retirement (almost 12 years from the navy and four and one-half years from Bird-Johnson). We are in Arlington, Va., close to our three children for a change. We're all happy, healthy, and busy."

We have received a substantial news release from the **Stanley M. Proctor** Co. of Twinsburg, Ohio, announcing the first major transition in leadership for the 30-year-old business. Founder Stan has moved up to the exalted position of chairman, passing on the job of president and CEO to son John D., an alumnus of the Sloan School. The Proctor Co. is a manufacturer's rep for more than 50 lines of industrial equipment. Starting in 1955 with an investment of $500, it has grown to a sales volume exceeding $10 million in 1985.

A letter from **Dick Feingold**, Palm Springs, Calif., urges your class officers to bestir themselves and start making arrangements for the 45th reunion before all the good places are taken. Dick offers his help on this project, whenever he's in the vicinity of Cape Cod, declaring, "I am as strong as a bull moose, and you can use me to the limit."

I'm relieved to announce there were no obituaries in this month's mail. Hang in there, classmates!—**Bob Rorschach**, Secretary, 2544 S. Norfolk, Tulsa, OK 74114

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Stanley Holbrook retired in May of 1984 after 32 years with Cryovac division, W.R. Grace. He served as technical director, director of engineering, and product line manager of films. The firm is the principal developer and supplier of shrink packaging materials and equipment. He and wife, Marjorie, just celebrated their 40th anniversary. They have two children, Karen and Douglas, both married, one now in Florida, the other in North Carolina. They also have "one incredibly charming granddaughter, three years old." They travel with their motorhome, the "Colossal Fossil!" He enjoys reading, music, construction—brick walls, houses, renovations, apparently his specialty. He also enjoys photography, genealogy research, and participates in civic activities.

Joseph Lester retired from the DuPont Co. in September of 1984, but writes that he is continuing to do consulting in the field of computer-aided engineering. He was the first chairman of the artificial intelligence technical committee of the A.S.M.E. computer division from 1983 to 1985. . . . **Robert Wood** retired September, 1985 from personnel management in Alcan Aluminum Corp. He received his masters in electrical engineering from Penn. in 1970. He says he is studying "in and out of school, computer science. You might say I'm pro-education!"

Joseph Crowley retired in December, 1985 from Honeywell's electro-optics division after 23 years as a senior mechanical design engineer. Joe is looking forward to improving his golf game and the joy of just puttering around!

Paul Heilman passes on the following about Paul and wife, Mardi, lunched with Sarita and **Gonzalo Docal** at the conference center operated by Uniroyal next to their headquarters. "Doc" as he is now known, is working through the intricacies of Uniroyal being a target company in a take-over bid. Paul also lunched with **Holton Harris** who is in the process of doubling his firm's plant size. Holton and wife, Jean, are pleased that their son Walter was admitted to M.I.T. Graduate School prior to having graduated in electrical engineering. Paul also talked to **John Gardner**, now retired, but keeping busy with consulting work on nuclear polymer aging and failure analysis. He is working with groups at the University of Connecticut and Franklin Institute in Philadelphia. John, or JB as we call him, enjoys sailplaning in N.H. and Vt., Eastern Pa. and W. Va. areas. These areas have long updrafts and the plane will soar for many miles. His son has taken up the sport, as well as wife, Dorothy. Paul reported that all three were sorry to have missed the mini-reunion in Williamsburg, but want very much to attend the next one.—Co-Secretaries: **Andy Corry**, Box 310, West Hyannisport, MA 02672; **Lou Demarkles**, 53 Maugus Hill Rd., Wellesley, MA 02181

46 40th Reunion

'Nother low bit count and another icy month in Denver, calling for another trip through the roster and Year Book. One little item via the Alumni Office is from **Bill Vannah** who shows up in the roster (but not the Book) as a Course II grad in the June class and an S.M. in '47. Seems Bill retired at the end of '85 from Foxboro Co. where as director of industrial standards he received the Aston-Polk Medal from the American National Standards Institute for promoting international trade through standards work. He's now consulting for the Instrument Society of America where he'll represent U.S. industry at European meetings developing standards for industrial electronics. Bill resides in Walpole, Mass., as of the latest roster. Other than that we'll look at some old grads not previously mentioned, with their "L.K.A.'s" (Last-Known-Addresses, in case you tuned in late):

Harold Jacobson, a Brooklyn boy clocked out of the September class with his course VI degree and went on to his S.M. a year later. He shows up as a program manager for Raytheon in Sudbury, Mass., and LKA'ed in Framingham. . . . **Hugo Johnson** hailing from Buffalo, and a Course X survivor, must be rich and famous and retired since his LKA is Hilton Head Island, a very nice neighborhood. . . . **Keith Lanneau**, up from Natchez, Miss., succeeded in Course VIII and returned to the south to become president of Beauregard Realty Corp. in Baton Rouge, where he also lives. . . . **Ted Kambour**, a Green Mountain lad from Barton, Vt., made the grade as a civil engineer in the September class and found his way back to Barton where he's the resident engineer for the state's transportation agency (but maybe that was a long time ago.)

Hans Lieske, a local out of West Roxbury and whom I have inexplicably overlooked before now, since he was a fellow V-12/Course XVIer, is shown as a senior project engineer at TRW in Redondo Beach and living in Pacific Palisades. I'll try to look him up next time I'm out that way. . . . **Manuel Llaguno** came from Monterrey, Mexico, to get his S.B. in Course XV and then went home again to become senior partner of his own company. . . . **Lewis Mann**, an uptown New Yorker, achieved his Course V letters and works for the V.A. Medical Center in Fresno, Calif., and also lives there.

Vaya con dios, amigos.—**Jim Ray**, Secretary, 2520 S. Ivanhoe, Pl., Denver, CO 80222

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Bob Peterson has maintained his long and fruitful relationship with Northwestern Mutual Life Insurance Co. selling life insurance. In addition to his work his cuurrent schedule includes spending two weeks in June and in September on Cape Cod. He owns a house at 43 Susan Ruth Rd., in Dennisport close to the ocean. He takes his boat and his golden retriever, Molly, and enjoys the change of pace from living near Washington, D.C.

Two years ago he bought a town house in Woodbridge, Va., which is about 35 miles south of Washington off Rte. 95. Woodbridge is a planned community with trees. Bob has not remarried since his divorce several years ago.

During the sixties Bob made many trips to Europe, but it has been eight years since his last trip to Switzerland. He attended a seminar for people interested in a safari in Africa, but has not made plans to go.

Bob quit smoking just a year and two days before our recent phone call. He is pleased by the results.

Gordon Johnson has taken early retirement as chairman of LogEtronics, Inc., which he helped found 30 years ago. Gordon has embarked on a new endeavor, under contract with the Agency for International Development to help developing countries privatize their state-owned enterprises. Recently, he was elected to the Society of Fellows, Graphic Arts Technical Foundation.

Dave Freedman founded Freedman's Bakery in Brookline more than 30 years ago. He retired eight years ago and his two sons are in the bak-

ery business that still bears his name. Since learning about the International Executive Service Corps. of Stamford, Conn., Dave has been to Egypt, Honduras, and most recently Kenya helping small businesses.

In November, Dave and his wife, Beverly, spent eight weeks working with 40 different government-subsidized bakeries. Until five years ago, most people five to ten miles outside the capital of Nairobi never ate bread, but rather a homemade corn mash tortilla. Some of the local bakeries use wood for fuel to heat the ovens and do their mixing by hand. Other bakeries have sophisticated equipment, but many of the owners didn't know how to use it.

Travelling from village to village in order to visit the bakeries involved rutted one lane mountain roads with no guardrail to prevent a 6,000 ft. drop. Beverly wrote that Dave was tremendous. He helped the African tribesman to improve their baking procedures so much that they were ready to make him King of Kenya.

Bob Wofsey retired from Arthur Young in September of 1985. He has joined Ward Howell International, Inc. as Director of Finance and Administration. The firm is a large executive recruiting firm. Bob has been very active in the M.I.T. Club of Westchester, and he is a member of the steering committee of our 40th Reunion Gift Committee. Bob and his wife Martha have two grandchildren. One youngster lives 20 minutes away and the other is 20 hours away. Bob's three children are married.

John Avallon has become a partner at Ernst and Whinney in Boston. John had retired from GTE Electrical Group as president. . . . **E. Thompson Westfall** is president and chief operating officer of Tacoma Boatbuilding Co. in Tacoma, Wash. He had retired from the U.S. Navy. . . . **Walter Lowrie** retired from Martin Marietta's Aerospace unit where he had been president. . . . **Mark Kirchner** is director of engineering technology at Boeing Commercial Airplane Co. He also serves on the Congressional Aeronautical Advisory Committee.

Robert Miller died last spring. He had been living in Sarasota, Fla., with wife. They had three children. Our sympathy to his family.—**Marty Billett**, Secretary, 16 Greenwood Ave., Barrington, RI 02806, (401) 245-8963

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Gerry Lessells informs us that he retired January 31, after 17 years with F. M. Huber Corporation's printing ink division in New Jersey—the first 15 years as technical director, the last two as manager of environmental services. Gerry and his wife, Jo, sold their home of 20 years in Edison, N.J., last June and moved into a travel trailer. He now plans to travel full-time around the U.S.A. and Canada for a few years and then settle down in the south-east, most likely Tucson. At that time Gerry hopes to do some part-time teaching. . . . **Roy W. Roth** sends a brief update note. As of February 1, Roy transferred from the U.S. Army Research, Development and Engineering Center in Natick, Mass. to Army Research Office, Research Triangle Park, N.C., to manage the army's independent research and development within industry. Overall, this program represents a $5 billion expenditure, primarily dealing with exploratory research programs contributing to the technology base. Roy is looking forward to seeing other alumni in the Research Triangle area.

Jim C. McAllister is planning to retire from McDonnell Douglas after 35 years and try something else—possibly some consulting in the telecommunications field. . . . **Norman F. Tisdale, Jr.**, is still working on proprietary product line in the steel industry. Norm has nine grandchildren, a tenth is expected. He tells us he is active in the same interests as in college—golf, ice hockey, and alumni fraternity. Norm has been married for 35 years. . . . **Arthur E. Wolters** retired in April, 1985 after 34 years with the DuPont Co., a career which spanned 21 positions in six geographical locations. He is now consulting, especially in the fields of polymer processing, technical and economic studies, safety, and training. Arthur and his wife, Patricia, are living in a home they built in 1982 on six acres fronting the Bohemia River. Their three children are grown. Jim, the oldest, is an architect practicing in Philadelphia. Daughter Pam is at the University of North Carolina, approaching completion of work leading to a doctorate in school psychology. Rob, the youngest is a marketing representative at Computerland in Nashua, N.H.

Donald B. Brah tells us that changes in business strategy at General Electric required a job change for him after 28 years. He was able to remain in Lynchburg, Va., his home since graduation. His new employer is Venator Systems, Inc., with headquarters in San Jose, Calif. Venator manufactures digital carrier test equipment for the telephone industry. Don's position as East Coast regional sales manager, affords him the opportunity for significant travel which he enjoys. . . . **Charles A. Church** is currently engaged as management consultant for oil and gas exploration and development and, also, computer software for N.C. CAD/CAM; as well as vice-president, director, Advanced Drilling Systems, Inc. in Dallas.

Bill Jarrold, son of Jerome T. Jarrold, '48, was the recipient of one of the Class of 1950 Scholarship Awards. The following is a letter from Dr. **Robert Mann** received from Bill's father: "My son, Bill, and I thank you and the Class of 1950 for the scholarship that you awarded him for 1985. As you can imagine, since you took part in the freshmen activities at Tech in the past, he is enjoying his experience immensely and appreciating the opportunity that is being given to him. In addition to his academic activities, he is participating in crew (freshmen, "third seat in the first boat"); Choral Society; has qualified to use the Tech dinghies; has attended lectures by Vonnegut, Morrison, Dr. Gray, and, of course, good ole Doc Edgerton. Upon coming home for Christmas he appears to have gained a few pounds in spite of his before-dawn awakenings to get to crew and lack of sleep, to some extent due to his four other roommates at Baker House. Again many thanks." As you can see, the scholarship was very much appreciated. To all who contributed, we thank you. Please consider the 1950 Scholarship Fund in your next contribution to M.I.T. and please be generous.—**John T. McKenna, Jr.**, Secretary, 9 Hawthorne Pl., 10-H, Boston, MA 02114

51 35th Reunion

Peter J. Phillion is a lecturer at the Northeastern University Math Department and a lawyer specializing in product liability, construction law, and patent law. He is also involved as an expert witness (his engineering training) in crane cases (they tend to tip over lately). . . . **Richard "Sledge" Hammer** reports his second son to graduate from M.I.T. will be Joe in December 1985. His first son Ed was graduated from M.I.T. in 1977. He says their other three children were normal and sent elsewhere. . . . **David Caplan** and his wife Elinor moved to the San Francisco Bay area in 1983. After exciting adventures with two companies, Fortune Systems and Convergent Technologies, he has settled down as a general partner with Adler and Co., a venture capital firm. Three of their four children are out of college, and the last one graduates in June.

Walter Wells is presently serving as a project manager in the S.D.I.O. in D.C. He just completed a four year tour as site manager of the M.I.T. Lincoln Laboratory's Kwajalein Krems project in the Marshall Islands, where he had spent two years of the sixties as Lincoln Lab's site manager of Project Press. . . . **Allan Elston** moved to California a year ago, leaving corporate management after serving first Pillsbury and then Sara Lee Corp. as group officer. He is enjoying a change as senior vice-president of SRI International (formerly Stanford Research Institute), heading up management and economics activities world wide. . . . **Donald L. Brown** has been an architect with Reynolds International for the past three years. He is now doing aluminum houses for various foreign missions in Africa.

William G. Rhoads moved to Lima, Peru, last July. He is in the agency for International Development mission working on macroeconomic development and debt problems. Prior to that he spent four years in Washington analyzing food and agriculture policies, getting governments to change their policies to promote more food production as a condition for receiving U.S. government food and loans (a billion dollar per year program). . . . **Richard Strauss** is president of Balston, Inc., in Lexington, Mass., a manufacturer of high efficiency filters for gases and liquids; also chief executive of the Balston Division (in addition to the U.S., the Balston Division has companies in Canada, England, France, Germany, Japan, and Singapore); and a director of the parent company, Whatman Reeve Angel PLC (Maidstone, England). He is married with three grown children (he says thankfully all out of college, but he is still paying off the HELP loans). **Howard L. Levingston** reports the 35th Reunion Planning Committee is going full speed with Ken Kruger as chairman. Howard says it will be another great reunion as is customary with the class of 1951. . . . An article in the New York Times dated November 19, 1985, showed that **David A. Grossman**, city budget director in the Lindsay administration, had returned from Washington to New York, where he was to be president of the Nova Institute research group. In remaining as a consultant, now part-time, to the World Bank, he was to go to Turkey and address mayors on an appropriate Thanksgiving subject, the New York City fiscal crisis and recovery.—**Gregor J. Gentleman**, Secretary, 600 Holcomb, Suite #1, Des Moines, IA 50313

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Since this month's news does not organize itself by any theme, I have organized it by course number, starting with Course II: **Joseph F. Alibrandi**, of Whittaker Corporation, has found that there is plenty of room at the top, by going from president and C.E.O. to chairman and C.E.O. **Clifford Moon** may also be ceaselessly striving, but he sounds a more relaxed note when he writes, "Margaret and I held a mini-reunion '52 in November, 1985 with Camille and **Carl Farrington** and Kay and **Frank Gauntt** on board our sailboat *Moonbeam* in U.S. and British Virgin Islands. Our adventure started with a near visit by hurricane Kate in Saint Thomas."

From course VI: **John Fitch** announces in a mini press release that he "will step down as executive director of the Association for Media-based Continuing Education for Engineers (AMCEE) in January, 1986. He has directed the activities of the Atlanta-based consortium of 33 engineering schools since taking early retirement from M.I.T. in 1981. In addition to its distribution of videotaped courses from its member universities, the association has recently inaugurated satellite television delivery of courses to its client companies and laboratories. John will continue with AMCEE part-time from his home in Concord." **Edward J. McCluskey**, who professes electrical engineering at Stanford, sends news of his family: his oldest son, Ted, got his M.D. from Washington University; his youngest son, Kevin, got his M.S. from Stanford, and married Ann Daggett; and his oldest daughter, Rosemary, moved back to Palo Alto from abroad with her husband and son.

And from Course X: **William Chandler** retired from SOHIO last fall, and is offering consulting services in technology exploitation/development, joint ventures, and licensing. He remarried last June; his bride is an active R.N. who works on the surgical floor of a nearby hospital.

Course XIII chips in with two items: **J. Ran-**

dolph Paulling was awarded the David W. Taylor gold medal for "Notable Achievement in Naval Architecture" at the annual meeting of the Society of Naval Architects and Marine Engineers last fall. **Charles M. Saltsman**, "now a vice president-ordnance division of Raymond Engineering, Inc. in Middletown, Conn., an M.I.T. Educational Counselor, and a member of the M.I.T. Alumni Council, represented M.I.T. at the inauguration of Dallas K. Beal as president of Connecticut State University." He is also a sculptor of wood mosaics, and recently completed a large commission for the Middletown library, entitled "Connecticut Creatures," a montage of birds and animals of the area.

Course XV"s entry comes from **Paul Lux**, who last year completed the Owner President Management Program at Harvard Business School, which he found potent and stimulating. He is president of David Sherman Corp., a producer of distilled spirits in St. Louis.

The Alumni Register says **Gene Amazon** graduated from course XVII, and that gives him the final word: "After two years in a Swiss bank I had to move on, so I'm doing independent computer consulting in Geneva and teaching at the Webster University branch here." Gene's note conjures up an image of bank security people finally discovering him lurking in the basement, but I don't suppose it actually happened that way.—**Richard F. Lacey**, Secretary, 2340 Cowper St., Palo Alto, CA 94301

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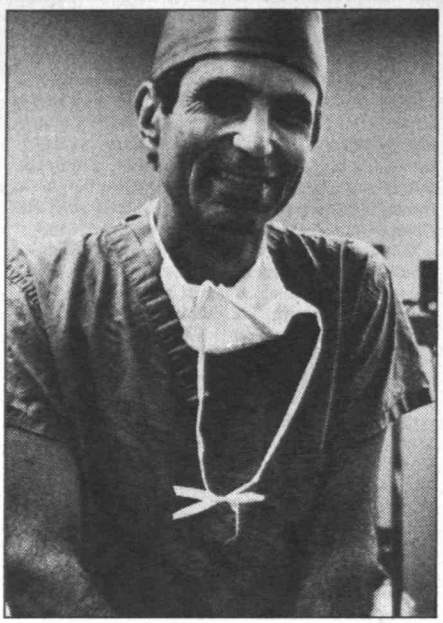
Albert C. Lee informs us that his oldest daughter, Lorraine, who received a "STAR" award from G.E. for 1985, started at Duke University last fall, and his second daughter, Tina, is a senior at North Carolina School of Science and Math. She is applying for admission to M.I.T. this fall. Their youngest daughter, Stephanie, is a high school school sophomore. Al is also a member of a team at G.E. that has just completed the production of a large number of amorphous metal core transformers as part of a project for the Electric Power Research Institute of Palo Alto. These transformers produce 25 KVA of power and are significantly higher in efficiency than ones with silicon iron cores that are currently used.

A newspaper clipping and a note from **George Michel, Jr.**, of Essex, Conn., informs us that he was elected chairman of the board of Stanadyne, Inc., in September, 1985. George has been with Stanadyne since 1970 when he joined as vice-president of administration and was most recently the vice chairman and chief financial officer. He is also serving as director for several community activites in the greater Hartford area. We wish him well in his new position.

J. Charles Forman has begun his eighth term in office this past year as executive director and secretary for the American Institute of Chemical Engineers. In addition, he is active as president of the board of directors for the Council of Engineering and Scientific Societies Executives and a director of the American Association of Engineering Societies.

We also received a brief note from **Caroline Herzenberg**. Her new book entitled *Women Scientists from Antiquity to the Present—An Index* will be coming out this spring, published by Locust Press. Caroline, we certainly hope your book sells many copies. It should be a very interesting one for all of us to read.

Among our classmates are some lucky people who are entering retirement. The first we heard from is **Morris B. Carter** who is retiring from Union Carbide Corp. after over 32 years of service, and also from **Alan T. Smith** who is taking early retirement from Monsanto after 31 years of designing and building chemical plants for that corporation. Al tells us that he is intending to devote a large part of his leisure time to promoting the sport of orienteering, which is a fun and fitness game involving finding your way using a map and sometimes a compass.



Steve Waltman, M.D., '61, ophthalmology professor at Washington University School of Medicine in St. Louis, is one of the few U.S. physicians (about 100) who now implant "living contact lens." These lens, made of human corneal tissue, dramatically improve the eyesight of patients with severe vision problems.

Also received a little blurb from a guy named **Wolf "Bill" Haberman** via the Class Notes portion of the Alumni Fund contribution form. He probably wishes he was in the same boat as Morris and Al, but he is still working at MITRE as an associate department head now after completing 25 years of service there. He is also still married to Berna after 32 years, and therefore, he says it is obvious that he believes in long-term commitments. His current work is in jam-resistant voice communications, which is a far cry from Course XVI. He and Berna have one grandchild, who is two years old.

Another of our classmates, my old friend **Sid Gravitz** from Course XVI, writes that he also just completed his 25th year, but at Boeing where he is the manager of tactical systems preliminary design. He and Phyllis have two daughters, Debbie who is a junior at Stanford, and Liz who is a sophomore at the University of Michigan. Let us hear more about what you're doing, Sid, and the rest of you too.

A recent article in the *Boston Globe* tells us that **Henry Kloss** is the majority stockholder of Kloss Video, a company which did about $20 million worth of business last year, and that he was just appointed president and chief executive officer. Kloss Video manufactures large screen projection video systems, with screens ranging from 4 ft. to as much as 15 ft. across for both home and commercial use.

It is with deep regret that we learned of the passing of **Warren L. Whalley** this past October. Warren lived with his wife, Priscilla, in Tulsa, Okla., and he will be missed by all of his friends and former classmates. Our sincerest condolences to Priscilla.—**Wolf Haberman**, Secretary, 41 Crestwood Dr., Framingham, MA 017011; **Joseph M. Cahn**, Assistant Secretary, 289 Bronwood Ave., Los Angeles, CA 90049

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A note from **Howard Brody** informs us that he has written a book entitled *Science Made Simple for the Tennis Teacher*. It has been published by the U.S. Professional Tennis Registry. . . . The last time that we mentioned **Colee Bresee** here it was about his championships in squash tournaments. Now we learn that his urge to keep trying has taken him back to school. He is just completing his second year in a Ph.D. program in neuroendocrinology at the University of California, San Francisco. Some of us never learn (enough).—**Edwin G. Eigel, Jr.**, Secretary, 33 Pepperbush Ln., Fairfield, CT 06430; **Joseph P. Blake, Jr.**, Assistant Secretary, 74 Lawrence Rd., Medford, MA 02155

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The news from our classmates is a little sparse this month, but what we don't make up in quantity we will make up in quality. **John Farmer** announced that he became a grandfather last June with the birth of Christopher Ross Farmer. Congratulations, John. Can we be getting that old? John also states that his current address is R.R. #2, Stowe, Vt. . . . **Joseph Carleton** is now working full-time as a consultant in accident investigation, an interesting combination of engineering and detective work. He and his wife, Ruth, had a leisurely vacation in Europe with three weeks in the Provence region of Southern France and a week in the Grindelwald region of Switzerland, enjoying the Roman ruins in France and the modern transportation equipment at the Swiss National Transportation Museum in Lucerne.

R.G. Dyck has returned to teaching and research in urban affairs and planning at Virginia Tech. Last summer he participated in the Savaria Summer School in Urbanization in Szombathely, Hungary. In November he gave a paper at an International Conference on Energy Planning in Dhaka, Bangladesh. . . . **William Brown** has been promoted to president and chief executive officer of McDonnel Douglas Helicopter Co. He was vice-president of engineering. . . . **Paul Goldan** reports on his latest activities at the NOAA/Aeronomy Laboratory. They include research on acid rain and atmospheric chemistry development of measurement techniques for measuring ambient levels of sulfur compounds, a survey of natural biogenic sources of sulfur compounds and an investigation of plant physiological mechanisms for the production of di-methyl-sulfide and related compounds.

Let's keep more information flowing on everyone's activities. It's fun to see the diverse accomplishments of our excellent class.—**Robert P. Greene**, Eastern Co-Secretary, 37 Great Rock Rd., Sherborn, MA 01770; and **DuWayne J. Peterson, Jr.**, Western Co-Secretary, 1841 Warwick Rd., San Marino, CA 91108

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David G. Quigley, M.D., is working as an orthopedic surgeon at Rhode Island Hospital in Providence, R.I. Dave and wife Eileen live in Seekonk, Mass. and are busy bringing up five children. . . . **David H. Mitchell** married Joan Cherry on November 23, 1985 and honeymooned in Great Britain. Congratulations and best wishes, David and Joan. . . . **Fred B. Bialek** has recently started a new company that produces a turnkey computer system to improve the productivity of telemarketing centers and sales and marketing departments. The company is International MarketVision, 130 Knowles Dr., Los Gatos, CA 95030.

Bruce D. Wedlock is the convention director for Electro/86, which will be held May 13 to 15 and willl operate from two locations, Bayside Convention Center and the International Trade Center.—Co-secretaries: **Robert Kaiser**, 12 Glen-

garry, Winchester, MA 01890, (617) 729-5345; **Caroline D. Chihoski**, 2116 W. Davies Ave., Littleton, CO 80120, (303) 794-5818

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At last, spring. Don't know about the rest of you, but it seemed like a long winter. Fortunately, the mails have brought fresh news of classmates to brighten the new season. **Ernie Flemig** reports that he and his family have moved back to Huntsville, Alabama where he is working for Morton Thiokol. He is currently on a temporary assignment as director of the company's strategic defence initiative programs. . . . **Leonard Timms** has been elected president of Consolidated Gas Transmission Corp., a subsidiary of Consolidated Natural Gas Co. in Pittsburgh. Previously, Leonard had served as vice-president of operations for the subsidiary.

At Kansas State University, **Larry Garvin** has been named as the new university architect, with responsibility for long range planning, capital improvements, renovation projects and facility planning. Previously, Larry had been associate dean and chairman of architecture at Texas Tech, assistant vice-president for physical planning and construction at the University of California, Berkeley; and staff architect at Harvard Medical School and M.I.T. . . . Nuclear Metals, Inc. has selected **Kenneth Smith**, the associate provost and vice-president of research at M.I.T., as a director of the firm. . . . **Sander Weinreb** recently presented a paper at the Boston Section of the Institute of Electrical and Electronic Engineers on radio astronomy. Sander is currently with the National Radio Astronomy Observatory where he specializes in the development of low-noise devices.

We received a nice note from **William Cooper** telling us: "I am now deputy group leader of the Magnetic Fusion Energy Group at the Lawrence Berkeley Laboratory. Glyde and I have two sons, Bill and John (twins) who are 14 and freshmen at Berkeley High. Weekdays and holidays are spent in the mountains or, more likely, watching Bill and John playing soccer." . . . Another letter arrived from **Paul Rothschild**'s wife, Rona, in which she reports that "Paul has left Owens-Illinois and joined the world of the entrepreneur! Paul and two other shareholders formed SYR, Inc., which in turn aquired Fremont Plastic Products Inc. in Fremont, Ohio. This company is a custom blow molder specializing in large parts for the automotive, agricultural, toy and recreational markets." . . . Now that it is the season, friends, spring some news on your trusty old class secretary.—**Michael E. Brose**, Secretary, 534 East Broadway, South Boston, MA 02127

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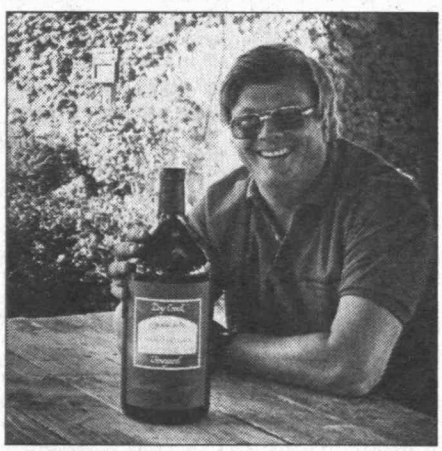
As I sit down at my terminal and watch the snow fall outside my window, I can take solace from the fact that by the time you all read these notes it will be well into spring with all the trees in bloom. I have a considerable number of notes to relay to you, so here it goes.

The first bit of news comes from M.I.T. Student Financial Aid Office which announces the first Class of '59 Scholar as Jill Peckingham, member of the Class of 1989. Jill, who is a daughter of classmate **George Peckingham**, graduated from Clinton Central High School where she was active in a number of service organizations as well as a member of the volleyball and tennis teams. Jill is considering a major in mechanical engineering. As of September, 1985, the Class of 1959 Scholarship Fund had over $200,000 in hand (not including outstanding pledges) which will generate approximately $12,000 in income to be used for undergraduate scholarships. Since Jill does not have need for that much scholarship aid, the remainder will be used to assist direct descendents of other alumni as directed by the Class.

A recent press release from The American Chemical Society announces that Professor **John Brauman** is the 1986 winner of the James Flack Norris Award in physical organic chemistry. John is being recognized for his work with charged molecules in the gas phase. John is currently the J. G. Jackson-C. J. Wood Professor of Chemistry at Stanford University. . . . **Dan Wang**, known internationally for his contributions to biochemical engineering, has been appointed to the Chevron professorship in the M.I.T. Department of Chemical Engineering. Dan is editor-in-chief of the *International Journal of Biotechnology and Bioengineering*, and was elected to the American Association for the Advancement of Science in 1985.

Allan Ream reports that his second son Knute is in his sophomore year at the Institute and "loves it." Allan goes on to say that he is still at Stanford, with computers and artificial heart work providing a substantial distraction from medicine. . . . Manuel Blum writes that he is currently a professor of computer science at University of California, Berkeley with his principal interests being number theory and cryptography. He is proud to relate that his son Avrim, is completing his junior year at M.I.T. with a dual major of physics and math and computer science. Manuel also informs us that two of his former students are now on the faculty at M.I.T. in the Department of Electrical Engineering and Computer Science. . . . **Phillip Johansen** dropped a note to tell us that he has been teaching for the past twenty years at St. Johns River Community College in Poletta, Fla.

Charles Crawford informs us that he is president on the N.H. High Tech Council and a participant in the Harvard Smaller Company Management Program. In addition, Charles is a member of the executive committee of the M.I.T. Enterprise Forum and an alternative delegate to the 1986 White House Conference on Small Business. . . . **John Benyon** writes that "despite President Reagan's myopic view of UNESCO, I am now in my 22nd year of working effectively on the design and construction of educational buildings. Over the past five years, buildings constructed in Asia, following UNESCO advice, house over 1 million (probably closer to 2.5 million) primary school children. My current post is that of principal architect for Asia and the Pacific." . . . **Nicholas Pryor** writes to say that after a career with the federal government including serving as technical director of the Naval Underwater Systems Center in Newport, R.I., he has left the civil service and is consulting in the Washington, D.C. area.



"Best Wine in California," according to the 1985 sweepstakes at the California State Fair. "This is the most satisfying award I have received during 13 years in the wine business," says David Stare, '62 (above), owner of Dry Creek Vineyard.

I received a sad and poignant note from **Neil Bernstein** which I would like to include in its entirety here. "I regret to advise the members of our Class of the death of our classmate, **Mitchell H. Dittmann**. Mitch and his wife Susan were killed on December 1, 1985 when the private plane he was piloting crashed during an attempted landing in bad weather at the airport outside of Atlanta. Mitch lived in Roswell, Ga., for the last ten years. He worked 22 years for IBM and was branch support manager in IBM's Atlanta operation. While their deaths were tragic and premature, Mitch and Sue enjoyed a very active life. Their interests and activities included sailing, scuba diving, tennis, softball, mountain climbing, and much travel in the plane which he co-owned. They are survived by two sons: Ken, age 23, a graduate of Stetson University, and Robbie, age 19, a sophomore at the University of Georgia where he is majoring in music education and music therapy. My wife Sandie and I and our families have remained very close with the Dittmann family over the years. We will miss them very much."

For those of you who could not attend the fabulous 25th Reunion and are interested in receiving the questionnaire results and picture/biography book, there are a number of these fascinatingly interesting documents still available. Just send me your class dues ($25.00 tax deductible, this year at least) and you will receive same by return mail. Also, send along any tidbits about either yourselves or a classmate for future class notes. Until then, take care and write if you get work!!!—**Arthur J. Collias**, Co-secretary, 24 Hemlock Dr., Canton, MA 02021

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Here's the remaining news from last month. **Michael E. Lee** is working at Xenergy in Burlington, Vt., and taking jazz dancing classes at night. . . . **Modesto (Mitch) Maidique** writes that he is professor of management at the School of Business, University of Miami; and director of the Innovation and Entrepeneurship Institute. He also serves on the boards of directors of ten start-up high-tech companies. . . . **Jerome E. Manning** writes that his daughter Patty is a member of the M.I.T. class of 1987 majoring in Course II. . . . **Philip H. Nelson** and J.R. Hearst had a book published last August titled *Well Logging for Physical Properties*. It describes the physical principles underlying the different well-logging methods—nuclear, electrical, acoustic, etc.—in use for petroleum and mineral evaluation. He is currently a staff petrophysicist with Sohio Petroleum in Dallas.

My old buddy **Larry Pitts** is associate professor and vice-chairman of neurosurgery and chief of neurosurgery at San Francisco General Hospital, where he is involved with human and experimental head and spinal chord injury work. His wife Mary is a photographer and children Jennifer and John are now 15 and 13. After 16 years in San Francisco he still does not feel like a permanent resident. . . . Next, I wish to publicly apologize to another old buddy, **Art Samberg**, whose name I misspelled in an earlier column and who is too much of a gentleman to complain. Keep up the good work Art, or is it Al?

Ted Sheskin was at the 1985 Space Tech Conference in Anaheim and presented a paper on the future use of an unmanned platform as opposed to a manned space station. His paper generated some interesting questions and discussions. . . . Professor **Carl Wunsch** of M.I.T. was awarded a new Secretary of the Navy Research Chair in Oceanography. Four such chairs were awarded and represent the renewed focus within the navy on basic oceanographic research.—**John E. Prussing**, Secretary, 2106 Grange Dr., Urbana, IL 61801

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What a delight it was to hear from so many of you who want to stay in touch with your classmates. Several took the opportunity to jot a note to enclose with a contribution to the 'tute; others wrote me directly. Here goes. **Bob Morse** reports he is a senior partner with a 30-year-old Washington, D.C. law firm, Kharasch, Morse & Garfinkle. In July he begins service on the board of the M.I.T. Alumni Association. His wife, Sandy, is a system analyst with Calculon, Inc. Daughter Lisa, a high school sophomore, and son Eric, a fifth-grader, are both straight-A students. . . . Twenty years ago **Larry Kazanowski** got his M.B.A. from Stanford. Since then he has been with Ford Motor, where he now is director of corporate strategy. He and his family had been in Brazil for a time, but have now returned, and live in Orchard Lake, Mich. His wife is a fundraiser for the Detroit Institute of Arts. His daughter, 7, and son, 5, are starting elementary school. Larry meets alumni almost every day, even when travelling in the Far East or Europe. . . . Lexington, Mass. is the home of **Steve Bernstein**, wife Stephanie, and children Debbie, 14, and David, 9. Steve heads the Communication Technology Group at Lincoln Lab.

For eight years **Mike Chessman** has lived in Portola Valley, Calif. He has been with Dysan Corp., now Xidex, five years. For the first time in several years he managed to spend Thanksgiving week in Boston. . . . **Richard Harris** is director of the naval systems engineering of MITRE Corp., McLean, Va. . . . As I mentioned a while back, **Woody Bowman** is a member of the Illinois General Assembly, he is now chair of the House Appropriations Committee, and running for his sixth term. He has also recently married. His wife, Michele Thompson, is a sociologist and is special assistant to the president of the University of Illinois. They do a good bit of commuting. Her office is at Chicago; his legislative office, about seven months a year, is at Springfield. Should you wish to write him, use P.O. Box 1799, Evanston, IL 60204.

This is embarrassing. I didn't know it, but **Joe Nathanson** is living—with his wife Sharon and daughter Amy, 8—about two miles from me, in a 100-plus-year-old Baltimore townhouse. He has formed an economic development consulting firm called Urban Information Associates, Inc. Last year he completed a major study of the prospects of the Kings Bay region of the Georgia-Florida coast. . . . Another new entrepreneur is **Ken Klein**, who started SoftPedal, Inc.—one-and-a-half year old developer of microcomputer systems for broadcasting and advertising. Ken is one of our few single classmates, and lives in Atlanta. . . . **Euo Menezes** is living in Cupertino, Calif. with his wife Eunice and children Justin, 8, Jeffrey, 6, and Jennifer, 3. He is a senior electrical engineer with Raychem Corp.

Last September **Henry Nau** attended his first Alumni Baseball Team Weekend. He says he had a great time: the varsity barely beat the alumni oldsters, 9-5. However, there were present only three '60s grads, and he hopes there will be more in the future. Thank you all who wrote. The rest of you please write or phone.—**Phil Marcus**, Secretary, 2617 Guilford Ave., Baltimore, MD 21218

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Hi! Some columns are more fun to write than others. There is handful of Alumni Fund envelope flaps which I will cover later but first some happy personal news. By the time this is published, I will have married **Louise Hersey** and the two of us will have settled into a new home in the Washington, D.C. area. Louise was born in Iowa, grew up in Natick and has an M.B.A. from Harvard. We have offered to give each other tee shirts of our respective schools (which we've agreed are to be worn only when taking out the trash). Louise and I met through mutual friends (Jane and Bard Crawford; Bard is M.I.T. '55) in early December. After two short dates and one long one, we made the delightful decision. Louise is currently a residential real estate broker in Lexington, earning a small percentage of very large dollar amounts. Her career directions in D.C. are TBD. Any and all of you passing through are welcome to visit. Otherwise, we'll see you at the 25th Reunion in 1989.

On to the envelopes! **Mark Lappin** reports that he is continuing to practice patent law at Lahive and Cockfield in Boston. . . . **Francis Tuggle** was elected an independent general partner of Equus Investments I, L.P., which is a limited partnership investment fund established to do leveraged buyouts. . . . **Eric Greenwell** is still working for Battelle in Richland, Wash. He notes that he continues to fly sailplanes and also is an instructor for the local glider club. (Having spent more than a few hours myself receiving flight instruction, I've noticed that instructors tend to be voracious consumers of antacid tablets—I was never sure whether it was the profession in general or the student in particular.) Eric's wife is still making pottery on a full-time basis. Their son has given up his "career" in roofing and returned to college to work on an electrical engineering/computer degree, for which his parents are grateful.

Don Brayton has rejoined Amray, Inc. of Bedford, Mass. They are the largest American manufacturer of scanning electron microscopes. He serves as their representative in southern California, Nevada, New Mexico and Arizona. His current title is either sales engineer or regional sales manager, "depending on to whom I am talking." . . . Linda and **Bill Young** of Greenwich, Conn., and their children Wendy and Danny enjoyed a fascinating trip to the Orient in August, 1985. They visited Tokyo (an aggressive and bustling city), Hong Kong (rainy and modern with lots of land left), Bangkok (with its breathtaking Grand Palace), Singapore (a fast-growing mixture of old and new) and Beijing (the most backward, but just beginning its emergence). The Young's note didn't say how long their trip lasted but it certainly seems as though they must have been on the go for quite a while.

I'll save the last few envelopes for the next column. Please drop a note if you get a chance and don't forget that Louise and I would be delighted to say hello to any '64 folk passing through Washington.—**Joe Kasper**, Secretary, 3502 Idaho Ave., NW, Washington, DC 20016

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I guess the Alumni Fund is doing its thing again, because this month's envelope had a few notes in it. On with the show!

Bill Brody is on leave from his position as professor of radiology at the Stanford Medical School, and is founder and president of Resonex, Inc., a company developing a new system for cardiovascular diagnosis using magnetic resonance imaging. . . . **Alan Schutz** was promoted last year to vice-president for engineering at Geophysical Survey Systems. Alan says that their ground-probing radar was recently sent to Turkey to search for Noah's Ark, and was seen on the 20/20 television show. . . . **Eric Westerfeld** is still at Adept Technology, after two years the second largest light-assembly robot manufacturer in the United States. Eric says that they even sell robots to Japan. . . . **Bruce Golden** is chairman of the High Technology and Emerging Industries Group at his law firm, McDermott, Will and Emery. Bruce is also co-chairman of the M.I.T. Enterprise Forum of Chicago.

Walter Miller writes that 1985 was a pretty good year. He is still on the faculty at the University of California at San Francisco where his lab cloned DNA's for three steroidogenic enzymes this year. He has also been editing a new journal, DNA, for the past three years and reports it is starting to do well as well as letting him use some of his Course XXI training to sharpen some scientific English. Most important, though, was the birth of Walter and Synthia's first child, Samantha Katherine Miller on December 6, 1985. Walter predicts she will be M.I.T. '06. . . . **Louis Kleiman** writes that the Endecon Corp., which he co-founded in May, 1984, just completed its first year of support for Hughes Aircraft's project designing the next air traffic control system for F.A.A. Louis and his partner went to the People's Republic of China in January to discuss air traffic control system modernization with government officials. . . . **Martin Thomas** writes that they are still enjoying the smaller town life style in Boise, Idaho, with lots of outdoor activities. Martin is involved with the arts, with memberships on the boards of the Boise Philharmonic Orchestra and the ballet company.

Alan Leslie writes that he continues to reside in the Park Slope area of Brooklyn. He is president of his own consulting firm, A.C.L. Management Services, Inc., involved in general and financial consulting. Alan's activities include sports and partaking of New York's cultural and recreational resources. . . . **Charles Deane** is active in the solution of advanced heat transfer problems at United Technologies Research Center, and in the operation of the Historical Society of Glastonbury, Conn., where he currently lives.

Art Bushkin writes that his business, Telemation, Inc. (I think--Art didn't say), continues to grow. In addition to telecommunications and trade policy consulting, he is negotiating joint ventures and raising investment capital. Art is also learning to speak Japanese. . . . This year is an important milestone for **Peter Gerstberger** since the Berwick Group, Inc., the Boston-based management consulting firm that he co-founded is now ten years old. Peter and his family continue to live in Andover, Mass. . . . Dr. **Dennis Bekeny** writes that as a pediatrician, he would like to remind us that we should "go forth and multiply." He also wrote that **Gene Chase** is now professor of mathematics at Messiah College in Grantham, Pa., and that the Rev. **John C. Larkin, III** is still pastor of a church in Londonderry, Vt.

Mark Tanenbaum received a U.S. Navy meritorious civilian service award for his work in ocean geodesy at the Space and Ocean Geodesy Branch of the Naval Surface Weapons Center at Dahlgren, Va. Mark has been at the Center since leaving M.I.T. in 1965. . . . **Michael Adler** received a gold patent medallion from the General Electric Research and Development Center in recognition for filing his twentieth patent application.

Finally, **Ed Burke**, classmate, former MITRE colleague, and sometime commercial rival, sent a note reflecting the usual competition, and hoping to see us on the Cape next summer. Thanks for the notes, folks. Keep it up.—**Steve Lipner**, Secretary, 6 Midland Rd., Wellesley, MA 02181

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Pete Denton took his kids, Tracy, 10, and Keith, 8, skiing in New England last Christmas and speculates: "Does middle age mean your son can ski faster than you?" . . . **Marc Schulman** is a vice-president of Salomon Brothers in New York City, where he manages the technology research group in the stock research department. . . . **Roy Gamse** is director of marketing for MCI Telecommunications Corp. He and his wife Joyce have two children, Nicholas, 3, and Laura, 1. . . . **Bob Karz** received his M.B.A. from the University of Rochester last June. He is still with Xerox. . . . **Gerald Siegel** is a senior manager with Peat, Marwick and Mitchell in Short Hills, N.J., where he provides management consulting on information systems. He lives near Princeton. . . . **David Mechler** left GTE in New York City in April 1984 to work for Emery Worldwide in Wilton, Conn., as project manager for development of microcomputer-based value-added products within an industrial marketing program. He continues to play cornet in "The Bourbon Street Seven," a Connect-

icut/New York area dixieland band. David returns home to Hawaii a couple of times a year and threatens some day to buy a one-way ticket.

Stan Rose is active in the New York Alumni Center. He chaired the spring and fall telethons, the latter raising close to $40,000. Stan is at Bankers Trust in New York where he was recently promoted to vice-president and group manager of distributed processing. His two children, Stephanie, 12, and Jeffrey, 11, are growing at an alarming rate, as the family moves into a period of teenage worries. . . . **Stuart Schaffner** proudly announces the birth of his first child, David Charles, a healthy and happy source of joy. Stuart is still at Massachusetts Computer Associates, where he builds software development tools and graphics systems.

Acknowledging that he has not written in ten years, **Larry Banks** thought it made sense to admit he is still alive. He received his masters/electrical emgineering degrees in 1969 and 1970, and writes: "I got married in '69, went to work for Hewlett-Packard Medical Group in '69, am still married and still work for Hewlett-Packard." He is now a R&D section manager for Hewlett-Packard Medical Andover Division responsible for developing the total engineering environment for lab productivity and efficacy ("meta-engineering.") He and his wife Liz, a journalist, have two daughters, Emily and Katie, ages 12 and 10. They live in Winchester, and Larry returns to M.I.T. from time to time as Hewlett-Packard Medical's Course VI-A Co-op recruiter. . . . **Russel Perkins** is director, Evaluation Division, for Naval Air Systems Command, and is a member of the Congressional Aeronautical Advisory Committee. . . . **Richard Rush** is editor of *The Building Systems Integration Handbook*, which was recently published by John Wiley & Sons, Inc. With contributions from more than 100 building and design experts, the book is a comprehensive handbook for design professionals.—**Jim Swanson**, Secretary, 878 Hoffman Terr., Los Altos, CA 94022

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This is Valentine's Day (at this writing), safely beyond the emotionally wrenching shuttle Challenger disaster. It was bad enough witnessing it in real-time on television, but then having to write and broadcast stories about it for over a solid day—almost too much to bear.

Monib Khademi married Julie Kiesehorst, a banker and native Californian in 1985. He was promoted to the post of executive for the advanced courses of Werner Erhard. Monib and Julie live in Mill Valley, Calif., after their Paris honeymoon. . . . **Norman Wittels** recently spoke before the local robotics chapter of IEEE. He was most recently working at Automatix, Inc., on machine vision but is now a consultant in that field. . . . **Charles Bures** is now the VLSI CAD R&D manager at Mass. Tech Park Corp. (when he was a Burton fourther he always dreamed of having all those "call" letters!). He is also a visiting lecturer at Northeastern University, where he teaches graduate courses in software engineering. . . . **Bruce Heflinger** writes, "I've done many sports junkets this year: to Alaska, Hawaii, Washington, and Massachusetts. Primarily though I've been bicycling, including several 100+ mile days and multi-day tours. I was recently elected president of my bike club, the Western Wheelers, of Palo Alto."

Chris Ryan writes: "My friends from the crew team will be amused to know that I have become a 'some-time' rower. I actually rowed in three races this past year, without much success. My construction business, started several years ago, is going quickly as we tackle hazardous waste clean-up projects. A large Japanese firm has invested in our company and is providing financial and technical resources that will accelerate our growth." . . . Now I know to whom I'm paying my large phone bills. **Mark Mathis** says that since the break-up of the Bell system he has been vice-president and general counsel of the four C&P Telephone Companies of D.C., Maryland, Virginia, and West Virginia. . . . **Jerry Raines** begins his 14th year as an independent consultant specializing in antennas and electromagnetics. He recently purchased a DEC LSI 1173 computer but has not yet figured out how to access all four megabytes of memory using the RT11 operating system. Jerry asks, "Any suggestions?" . . . **Ka-Hung Fogg** writes simply that he has just returned from Hong Kong after more than five years absence.

Steve Rothman says that on April 1, 1985, he left a 16-year career at DEC for Kurzweil Applied Intelligence, where he is running the hardware development efforts. The company makes large vocabulary speech recognition systems. He reports that the company is staffed by a relatively large number of M.I.T. grads (who else?) and a couple of students (who probably do most of the work, ed.). . . . **Kathryn Kanarek James** writes from a notorious spot: "I was promoted to GS-13 at Ft. Leavenworth in September 1984 and have been working on TENCAP, a program to bring intelligence information to the tactical commander. It's a great job, with the only negative aspect being that all the meetings are held in windowless rooms. I have really learned to appreciate sunlight." And on that solar note I end this refrain, thrust home!—**Eugene F. Mallove**, Secretary, 11902 Paradise Ln., Herndon, VA 22071

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Steven Cushing has joined the faculty as an assistant professor of mathematics and computer science at Stonehill College. He received his M.A. and Ph.D. from University of California at Los Angeles. . . . **David Asbell** is director of the Advanced Components Test Facility at Georgia Tech. He hopes to become heavily involved in solar thermal power generation for a space station. He also enjoys paddling, running, and landscaping. . . . **Tim Gilmore** has been doing contract work in environmental/occupational medicine and family practice. He continues to be involved in skiing and rugby. . . . **Stephen F. Cooper** proudly announces the birth of his second son, Alan, on July 3, 1985.

Leland Schaeffer and his spouse recently moved to Los Altos. He joined Counterpoint Computers in San Jose. . . . **David A. Saar** announces the birth of twin baby girls in March. . . . **J.O. Enwonwu** is a member of the board of governors at the University of Maiduciuri in Nigeria and a member of the board of governors of the Architects Registration Council of Nigeria. He is the developer/owner of the International Class Niger Heritage Hotel. . . . **Paul A. Lawson** is currently engineering director of Energy Sciences in Woburn. He and his spouse, Annette, have two children. Annette is engaged in private law practice.

Robert Frankston is the chief scientist of the Information Services Division of Lotus Development. . . . **Kenneth A. LaBresh**, M.D. has entered private cardiology practice in Providence, R.I. He and his spouse have one son. . . . **Reid Ashe** and his spouse are now living in Miami and have also announced the birth of their first child. He writes that they spend their weekends sailing and jogging on the beach or island hopping in a recently acquired Piper Aztec. He continues to be involved with Viewtron, a subsidiary of Knight-Ridder Newspapers that is developing an on-line computer service. His wife is a part-time editor for an employee magazine of Knight-Ridder Newspapers.—**Robert Vegeler**, Secretary, Beers, Mallers, Backs, Salin & Larmore, 2200 Ft. Wayne National Bank Bldg., Fort Wayne, IN 46802

71 15th Reunion

Michael Shao is the project leader on the design of the Mark III Astrometic Interferometer, a highly sensitive instrument for accurately measuring the angles between stars to several nanoradians. Michael received his S.B., S.M. and Ph.D. from M.I.T. in Course VI, writing his Ph.D. thesis on the Mark II Astrometric Interferometer. . . . **Peter A. Stoll** writes: "I am still a dirty hands design engineer working for Daisy Systems, but I edged toward professional respectability by giving a paper at ICCD '85 on PMX, the logic simulation tool I have given the last two years of my life to." . . . **Charles O. O'Brien** is now the senior vice-president, parent and president, Pharmaceuticals Division, and chief operating officer of Ciba-Geigy Corp., Ardsley, N.Y. . . . **Daniel Weinberg** co-editor of *Fighting Poverty: What Works and What Doesn't*, published by the Harvard Press.

N. Laura Middleton writes: "I have completed a residency in psychiatry in 1984 and am now in private practice as well as working part-time as a community mental health agency. In 1980 I married Ed Nowak (M.I.T. '73, Course VIII), a friend from University of Maryland grad school days. After I finished a stint in the PHS, first in Arkansas and then in Provincetown, Mass.; we moved to Burlington, N.C., where I did my residency and he works for IBM." . . . **Lloyd Marks** is assistant professor of pediatric division of pediatric cardiology and assistant professor of electrical engineering, State University of New York at Stony Brook, Stony Brook, NY 11790-8111. He was recently awarded a patent: Computer Assisted Admittance Plethysmograph (Patent #4,548,211). . . . **Craig J. Richardson** announces the birth of his second daughter, Emily, in March 1985. Dr. **Jerome L. Bushnell** is a physician in family practice in Issaquah, Wash., married with children age three years and four months.—**R. Hal Moorman**, Secretary, P.O. Box 1808, Brenham, TX 77833

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Lots of news and lots of new kids this month! **Dave Burns** and his wife, Deborah Hafer Burns, '74, are both at Hewlett-Packard. Dave is designing computers while Debbie is in optoelectronics. "Our biggest project this year was our new daughter, Katrina Elizabeth, born in October." . . . **Michael J. Rowny** reports, "Melissa and I received a belated Christmas present, our second daughter, Julia, born December 28th. I continue as a senior vice-president, finance of MCI." . . . For **Bob Reiter** "the big news this year is the birth of Rebekah Childs Reiter, our third child. I also got promoted to advisory programmer in IBM's Federal System Division in Gaitherburg, Md. Praise the Lord for his blessings." . . . **John Krzywicki** announces the birth of Peter Christoph on May 30. "With two healthy boys, (John Carl is 3), a very attractive management consulting practice, Morris dancing (performed at the Cristmas revels) and other dance events, Lelon and I are very busy." . . . **Eugene Kroch** reports, "This year we expanded our family by another boy, David Andrew in July. I am still at Penn Economics. Philadelphia is a great city."

Mark Mitchell writes, "Having survived 25 months of duty on the *Enterprise*, I have re-established contact with my family and moved back to the Monterey Peninsula. I am now teaching operations research at the naval postgraduate school in Monterey and enjoy playing with my six-year-old son Joseph and almost two-year-old Elizabeth. My wife, Konia, was very glad to give up her role as both mother and father for the last two years and is happy to be the mother only." . . . **Bob Fourer** is spending a year at Bell Labs, Murray Hill, N.J. on sabbatical from Northwestern. . . . **Leonard Sigal** joined the faculty of Upstate Medical Center in Syracuse, Division of Clinical Immunology and Rheumatology, in July 1984. He will be marrying Barbara Snyder (Barnard '70), a pediatrician at the University of Rochester. . . . **David Morgenlender** started his own consulting firm, Morgenlender Associates, specializing in software development for micro and minicomputers in

management planning, land development, and marketing mostly in the upper midwest, expanding to the west coast. He teaches in the Business Administration Department at the University of Wisconsin in Eau Claire.

Robert Abrams has joined Peat, Marwick, Mitchell in San Francisco as a senior manager in the information systems services division. He and his wife, Joan live in San Francisco. . . . **Carl Whittaker** has been a partner in Bain & Co., the corporate strategy consulting firm, for four years. He is about to join Bain's growing Tokyo office. . . . **Steve Henry** writes, "The last two months have been a time of change and progress for me. In November I joined the law firm of Greenfield and Sacks, P.C. in Boston, where I am 'of counsel.' In December I became president of the Boston Patent Law Association."—**Dick Fletcher**, Secretary, 135 West St., Braintree, MA 02184

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A pile of letters greet me this month as I root through the mail. **Alan Lehotsky** writes of missing a career as a ski bum. He lives in Lexington and invites all BTB's to visit when up that way. . . . **Carl Rosenberg** is still in academic medicine, applying for a grant, for which we wish him luck. . . . **Sally Boyson** graduated medical school at Penn in 1979, did her internship and residency there, and continued as a post-doctoral fellow in neuropharmacology. She is now an assistant professor at Penn. Sally and cats will be moving to Denver in July, in a similar position at Colorado Medical Center.

An old bowling bud (who wouldn't remember me), **Mark Liss**, was married last June to Patrice Tyler. The next month he began his practice in gastroenterology at New Rochelle Hospital and at Montefiore in the Bronx. He notes that an old roommate of his, **Ron Gittelson** moved to Switzerland with wife Margrit. **Peter Buchanan** is working for the Ontario Ministry of Industrial Trade and Technology in Toronto. Peter recently returned from a trip to London, Paris and Rome. . . . **Doron Holtzer** has survived Sohio's latest reorganization and is now managing a staff of eight programmers and analysts supporting a wide variety of applications for Sohio's corporate services.

John Wall "at last had a moderately eventful year." He was promoted to unit leader of the diesel and aviation fuels group at Chevron Research, and received the Horning and the Colwell awards for emissions research on diesel engines. Daughter Katie is still on track for the class of '04.

Tom Stagliano gets the class of '73 order of merit for an actual letter. Tom is now manager of west coast operations of Kamon Avi Dyne of Burlington, Mass., but is still working out of his apartment. He just returned from a vacation in Hong Kong and Thailand, asking after the current whereabouts of Princess, our classmate. (Anybody know?) He's still playing hockey and soccer, refereeing the latter for NAIA. Tom plays hockey with a group of ex-pros and entertainers, including Michael Keaton (representing the movies) and a few of the L.A. Kings hockey team. His number is (213) 207-1635 in L.A., if you are ever there.

I am planning to head out to Salt Lake City in July for the SPEBSQSA contest and convention. The Alexandria, Va. chapter, to which I belong, is the new Mid-Atlantic District chorus champion, and will compete with 15 other chapters for the title of International Champion. We've been second twice, but this could be it. In other news, there is none. So write.—**Robert M. O. Sutton, Sr.**, Secretary, "Chapel Hill," 1302 Churchill Ct., Marshall, Va 22115

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Rudy Miller finished his residency and fellowship training in radiology (angiography) at the Brigham and Women's Hospital in Boston. As of July 1, 1985, Rudy was appointed assistant professor in radiology at the University of Texas, Dallas, Health Science Center. . . . News of a wedding: **Lorna Giles** and **Kenny Armstead** were married on July 14, 1985 in Maynard, Mass. and now reside in New York City. Congratulations!

Ned C. Forrester writes that after ten years at Digital Equipment Corp., he is now at Woods Hole Oceanographic Institute in the ocean engineering department working on a new propulsion system for the research submersible *Alvin*. . . . **Frank Klotz** is now working for Equatorial Communications Co. in Mountain View, Calif., developing software for data communications via satellite. . . . **Richard Withers** is the assistant leader of the analog device technology group in Lincoln Lab's solid state division. His work includes surface-acoustic-wave, superconductive and charge-coupled device development and applications.

Lawrence M. Devito is still "living in the suburbs" (Tewksbury, Mass.) and still designing integrated circuits for Analog Devices in Wilmington, Mass. . . . **Jack R. Swan, Jr.** is currently president and co-owner of Market Information Technology, Inc. in Boston. His company designs and develops computer software for realtime communications applications. That completes our electrical engineering newsletter.

Now for some additional news. **David Jessich** has been in Saudi Arabia for three years. He is still working for Exxon (on loan to Aramco) as lead petroleum engineer in Safaniya Field (1,500,000 bbls/day potential). . . . Another one of our classmates recently made the trek east. At the end of February, **Rich McCarthy** transferred to Saudi Arabia, still working for Arthur D. Little as an energy consultant and system development overseer. Accompanying Rich on this two and a half year jaunt are his wife Judy and his brand new baby daughter, Lauren Anne, born October 11, 1985. Congratulations!

And more congratulations are in order for two more classmates who have recently become parents. **Peter Mancuso**'s first child, Stephen Mariano Mancuso was born on August 15, 1985 and has "changed his parents' lives in a very wonderful way." . . . **Patricia R. Callahan** had her first child in March, 1985, Katherine Callahan Dee. Pat had additional cause for celebration as she was promoted to senior vice-president at Crocker Bank in October.

That's all for now. I am always happy to hear from you. And for those of you who hate to write, call me at work and let me know how you're doing.—**Jenifer Gordon**, Secretary, c/o Pennie & Edmonds, 1155 Avenue of the Americas, New York, NY 10035; or 18 Montgomery Pl., Brooklyn, NY 11215

76 10th Reunion

Please send news. The mails have been very sparse of late. Word of **Roger Allison**: he has joined the international construction consulting firm of Wagner-Hohns-Inglis, Inc., in their Kansas City, Mo., office as a consultant. Prior to joining Wagner-Hohns-Inglis, Roger was in the U.S. Army Corps of Engineers for nine years. While in the Corps, he had a company command of an engineer batallion in Korea, plus he was a project engineer for the Corps in the Kansas City district and was the organizational effectiveness staff officer at the U.S. Army Training Center, Fort Leonard Wood, Mo.

Congrats to **Stuart Morgan** on his marriage to Catherine Flint. Stuart is a founding partner of Kaplan-Morgan Architects in San Francisco, where they make their home. . . . And a letter from **Neil Lieblich**, who is a pediatrician in Kingston, N.Y.. "This has been a banner year for the Lieblich household. . . . It has been a long time since my debut as Lazar Wolfe in the '76 M.I.T.—M.T.G. production of *Fiddler on the Roof*. I would love to hear from any past members of the troupe. Also, any messages or info about the '76. Logarythms would be warmly received. . . . As for my family, things couldn't be better. My wife, Joyce Holzman-Lieblich (Simmons '76) is president of Hadassah. We've had our first child, Ross Henry, this past year. . . . I am now board certified in pediatrics. My practice is in the heart of I.B.M. country in Kingston, N.Y."

As for your secretary, both Rita and I truly regret that we will not be able to attend the 10th reunion. By the time these notes are printed, our child may have been born. It is my hope that you will reelect me class secretary for another five-year term, and that several people will help collect information for subsequent issues. I still find it amazing to think that 10 years have elapsed, and so quickly. It just doesn't seem like it, although we all know it is so. As for the futures markets, I am having a gut-wrenching time in stock index futures, bonds, and foreign exchange. Over the last 10 years, I have seen and participated in some amazing movements of the financial markets. We continue to live in wild times, from this perspective, and I continue to relish it. As we move through 1986, I see no end to the roller coaster, and with it, opportunities.—**Arthur J. Carp**, Secretary, 110-07 73rd Rd., Forest Hills, NY 11375, (718)544-5136

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We've got a whole variety of news this month. **Heather Hazard** writes: "True to my Scandinavian roots, I will be marrying a wonderful Dane named Christian Erik Kampmann this June." After meeting at Dartmouth in 1982, Heather and Christian Erik spent some time working in London. Now they're about to finish their Ph.D.'s ("at long last")—Heather from Harvard's Kennedy School (applied economics and game theory and Christian Erik's from the Sloan School). When not writing their dissertations, they spend weekends fixing up their 292 year-old house in Ipswich, Mass.

Sue Kayton tried to send me a boring postcard from L.A., but the best she could do is a picture of spike-haired punk rockers. Thanks for trying, Sue. Sue's big news is that her son Daniel Joseph is now one year old, and Sue in enjoying being home taking care of him. "If anyone had predicted that ten years ago, I'd never believe them. You should see him sitting at the computer wearing his M.I.T. T-shirt." The T-shirt is courtesy of Sue's old roommate, **Julie Kozaczka**, "who is alive and well in Watertown, Mass. working at Mass. General Hospital teaching doctors how to spell 'computer' and a care and feeding of thereof."

In addition to working on his post-doc ophthalmology fellowship at Washington University in St. Louis, **Barry Linder** has been up to his eyes in space flight. Barry was appointed to the board of advisors of the Society Expeditions' Project Space Voyage in Seattle (working on public access to space by the early 1990s; for reservations call 800-426-7794). He was nominated to NASA's technology developments advisory panel for space stations. He is also been keeping busy with NASA life sciences at Johnson Place Center. And, if he has time, he will start his residency in ophthalmology in July. . . . Also practicing medicine at a prestigious academic medical center is **David R. Brown**, who has just been appointed a staff physician at Johns Hopkins in Baltimore.

Eric Ziering writes that he is "alive and well and living in the Boston's South End. I was married on September 21 to Bonita Ann Ciambotti of Altoona, Pa. I am currently a vice-president (and founder) of Caliper Corp., a marketing research and business consulting firm located in Newton, Mass." The company also does a steady business in transportation planning, logistics and mainframe and micro software.

Other new marriages: **Gerry Epstein** got married on June 30 ("I prefer to call it July 0) to Ellen Mika. They are now living in Takoma Park, Md., just north of D.C. Gerry still finds working at the Congressional Office of Technology Assessment

very interesting "especially since the release in September of our study on ballistic missile defence technologies (aka Star Wars). My next project will probably be an assessment of magnetic fusion technology." . . . **Carolyn Myers** married J. David Conrad III last November. Carolyn has been at Bethlehem Steel for five years.

Engagements: I saw **Phil Kesten** at a telethon recently. Phil finished his physics Ph.D. (University of Michigan, Ann Arbor) and is now working at Brandeis. This June he will be getting married to Kathy O'Shea, who is "NOT in physics!" Also engaged is **Alan Markum**, to Barbara Strauss of Marin County, Calif., "a physical therapist, who gives great massages!" Alan is doing highly technical marketing support for Sun Microsystems. Alan reports that he recently had dinner with **Jim Heeger** and his wife Darryl; Jim is working in a manufacturing division of Hewlett-Packard.

No, he doesn't have children of his own, but Craig Selvage, '78, contributes to entertaining them. He designs toys for Hasbro, Inc. (world's largest toy company) in Pawtucket, R.I.

Children: **Vinnie Paolino**'s son "Dr." David Paolino is now two. Vinnie, David and Paula just moved to their new house in Bradford, Mass., near Vinnie's dental practice. . . . **Doug King** and **Sharon Pastorizia** live with their one-year-old son Alden. Doug and Sharon still dance in a performing group (the Westwind International Folk Dance Ensemble), but Alden won't do anything but break dancing. They also recently got together with **Steve Melnikoff** and **Libby Seifel** to raise $7,000 for the Women's Scholarship Fund of the Northern California M.I.T. Club.

More kids. . . **Cicely Rodal**, husband Jose, and two-year-old Jocelyn live in Clark's Summit, Pa., near Scranton. . . . **William Kuttner**, his wife and two sons (and one tenant) live in a 19th century house in Charlestown, Mass. . . . **Frank Chung** has two kids, ages 2 and 1. . . . **Tina Kangas Van Dyk** has a 20-month-old son Peter; Tina is still working for DuPont.

Bill Duke III named his son (you guessed it) William Duke IV. Bill III is an assistant professor of geoscience at Penn. State. . . . **David Bovarnick**'s daughter is only two, but he is already preparing her for an M.I.T. education. (I can't guess what torture that poor kid is going through.) . . . **Art Wendel** and his wife Marianne send word of their two children (Christine, 3, and Matthew, nearly 4). Art is a U.S. Air Force staff scientist in Melbourne, Fla. and wants to get back to New England.

Still More Kids: **Don Shulsinger** and his wife Ariela had a baby girl Tamar last summer. . . . My old roommate, **Peter Shaw**'s daughter Allison is just about to start walking. Pete, wife Kathie Kellie and Allison live in Woods Hole, Mass., where Pete works for the Woods Hole Oceanographic Institute (WHOI). Also at WHOI is Pete's and my former roommate **Spahr Webb**, who reports that he is "little beyond alive and well and living in Falmouth."

I recently spoke to **John Marcou**, who these days works as a petroleum engineer far off in the wilds of Anchorage, Alaska. John's wife, **Roby Rosen**, finished her pediatrics residency at Stanford last summer, and now practices pediatrics full-time, taking care of their ten-month old son Kevin. Meanwhile John's old roommate, **Todd Buikema** is also working in Anchorage and also has a young son (Lindsey) who is four months younger than young Kevin Marcou. . . . **David Blaker** has a new job (at Bell Labs in N.J.) and a new daughter (six-month-old Sarah Elizabeth). David is also working on his masters at Lehigh in his spare time.

Sam and Carol (Brown) Senne have three kids, the leading intellects at the local nursery school; names: Christine (age five), Brian (four), and Samantha (three). Sam and Carol run their own contracting and building outfit. . . . Congratulations to **Gene Scoville** and his wife Betty. By the time this is printed Betty should have given birth to a playmate for their daughter Amanda.

Chris Vodges had to give up skiing when she moved from the San Francisco bay to Ft. Lauderdale last summer—so she took up scuba diving. Chris is working for Cordis in the angiographic products division. . . . Also recently moved South is **Nayyar Butt**, who is in IBM's marketing training program. "The job is exciting with plenty of contact with new employees and I find Texas a lot more civilized in winter than the Northeast."

Jeff Van de Grift writes that he is living in the suburbs of Boston and working for Bolt, Beraneck, and Newman in speech processing. . . . Also in the Boston area is **Lee Gavens**, who is in his first year at the Harvard Business School. . . . **Larry Yablong** is still living in Manhattan. He is now working for Merrill Lynch's investment banking division, and enjoying his many business trips—especially to his home town, Chicago.

Lawyers: In their classic *Adam's Rib*, Spencer Tracy and Katherine Hepburn warned that lawyers should not marry other lawyers. ("It breeds tension and idiot children.") Apparently this warning was not heeded by **Warren Loui**, who has now been married for about half a year to Rose Chan, a third-year law student. Warren works in corporate law for Simpson, Thatcher & Bartlett in N.Y. (he spent a year in their Hong Kong office). . . . Also recently married is **Carrick Brook-Davidson**, who is practicing in Washington, D.C. Sue Hansen (with an "e") is not yet a lawyer, but she is thinking about it seriously. She is now working for University Bank, owned by the apparently "infamous" Harold Brown, who was recently indicted.

More lawyers: **Delonia Watson**'s practice is apparently going well; she was appointed assistant district attorney for the appellate division in Dallas, Texas. . . . Shortly after his return from a year in the London office, **Don Lampe** has now changed firms, and now works for a large corporate law firm in Greensboro, N.C. . . . **Al Knauf** reports that he is doing environmental and hazardous waste law in Rochester, N.Y. Al recently bought a house, where he can continue to throw big parties (such as the one where I met my wife). Recently, Al threw the biggest party in Rochester history, raising $28,000 for charity.

A cryptic note from **Robert Weiss** and his wife Katrina. After two and a half years of marriage they are doing well, considering they are in "the middle of nowhere" (he doesn't say where). He says that they are anxiously waiting to get back to New York or somewhere close to the ocean. . . . **Craig Shapiro** reports that he is a staff physician at the N.Y.U. Medical Center in N.Y.C., and is living on the east side of Manhattan.

Bill McGrath felt a bit adventurous after getting his Ph.D. in physics from Berkeley last June. So, "giving in to my urge to explore new situations, I took a post-doctoral research position at Chalmers University of Technology in Gothenburg, Sweden." . . . **Robert Wargo** is senior research engineer with U.S. Steel in Pittsburgh, focusing on iron ore research. . . . **Gary Simpson** reports in that he is a filed application engineer, marketing chips for NEC Electronics in Burlington, Mass.

David Loo reports that he is still working for TASC, but that he has moved to Detroit to open a new branch office. . . . **Ely Dahan** reports that he has acquired a computer business in Baltimore, and it's doing well. He and his wife Marsha designed a house and had it built. . . . **Elizabeth Cavicchi** is working on research for a new documentary series for WGBH television (public TV). . . . A report from **Italo Visco** tells us that he was recently appointed a director to Hughes and MacCarthy, Inc. of Framingham, Mass. . . . **David Nadler** left Chase Econometrics and has started his own company, Nadler Associates, which manufactures electronic sensing equipment and software products.

As for me, well, there is not much news. I still really enjoy my job at University Hospital in Boston, and am rapidly getting involved in a bewildering variety of hospital policy issues. I just discovered that my boss's new boss is a former M.I.T. roommate of an old friend of mine. Those 'tute connections can pay off after all. Meanwhile, my wife Yuko is in the midst (did someone say "mists"?) of her second semester at M.I.T.'s Sloan School. Anybody out there with a summer job for her (preferably high tech marketing in the Boston area), give me a call.

Send news and boring postcards to **David S. Browne**, Secretary, 50 Follen St. #104, Cambridge, MA 02138, (h) (617) 491-5313

79

Greetings, classmates. It's time once again for enquiring minds to get their fill. All the news that fits, we print!

Don Richards dropped me a note to let me know that he received his M.B.A. from the University of Chicago last June and joined Bankers Trust in New York City as an associate. He is currently doing work in artificial intelligence. . . . **Bonnie Mason** called recently from the M.I.T. Alumni Center in Cambridge, where she was participating in the Alumni Fund Telethon. Nothing new for Bonnie and husband Al Chock, '78, except to say that, contrary to reports in the Class of '78 column, they have *not* purchased a house in Melrose, Mass.—they are merely renting (perhaps my colleague from the Class of '78 can read fantasies. If so, we're all in trouble!)

This month's Greatest Idea prize goes to **Peter Dreher**, who writes, "After watching a sunset from the warm shower and jacuzzi of a Cornell University waterfall, I lamented M.I.T.'s lack of a similar facility. Perhaps as a class gift, we could provide a similar man-sized waterfall by modifying a portion of the Rogers Building steps?" (Sounds good to me!) Peter adds, "I am currently the senior project engineer for ENG, Inc., a petroleum, mechanical, and chemical engineering consulting firm in Cambridge. I report to our company president and am managing the engineering and installation of a geothermal well near Syracuse, New York." . . . **Kelly Hartshorn** writes, "We moved to the San Francisco area in August with our three-week old son. Since then I have started back to work with Chevron and am really getting to like California life!" . . . **Joel Mattox** recently became engaged to Karen Perizzolo, '82. Congratulations!

Rick Halvorsen is a practicing attorney in Tacoma. He reports that **Dave Heller** is also in Seattle. Dave is married to Andrea Darvas and they have three-month old twins. (Double trouble!) . . . **Doug Morrow** is "manager of the liquid process production area for the Los Angeles plant of Lever Bros. (making Wisk, Snuggle, etc.). Speaking regularly at Toastmasters meetings, sailing a

lot, and generally enjoying Southern California." For the edification of your faithful secretary, can anyone out there tell me what Snuggle is?

Richard Gray graduated from Wharton in 1982 and is now on his third job, with Arrow in Chicago. . . . Red and **Dick Cook** are "happy down in Brockton with daughter 'Allie' (born April, 1985). Working at Gillette, playing Lacrosse, and loving life!" . . . **John Fratamico** is manager of technical development of Alcoa Defense Systems in San Diego. . . . **Becky Waring** writes, "After working for the Environmental Protection Agency for a couple of years, I returned to M.I.T. for my masters from Sloan. I am currently in the Ph.D. program in system dynamics at M.I.T., where I've been a resident tutor in East Campus for four years. M.I.T. and Cambridge are changing rapidly, both for the better and it's nice to watch! Come visit and I'll show you what's new!"

Michael Good says, "I'm still working at Digital Equipment Corp. but I'm now at the Spit Brook Road plant in Nashua, N. H. I am in the software human engineering group, where we try to engineer usability into a variety of software products—putting some engineering effort behind phrases like 'easy to use' and 'easy to learn.' I'm also still living in Arlington (a long commute), and playing trumpet in the M.I.T. Concert Band, the Somerville Brass Quintet, and the Sudbury Savoyards orchestra." . . . **Nola Hylton** recently finished her Ph.D. in physics at Stanford University and will be continuing her research at a firm in California. . . . **Bob Light** writes, "In January, Phillippe Villers, S.M.'60, Doug Wilson, '78, myself and six others founded Cognition, Inc. Cognition will be the first company to introduce a product in the emerging mechanical computer-aided engineering (MCAE) market. Suffice it to say, this is taking up ALL my time."

Your faithful secretary will be departing for Acapulco in a few days (it's February now, and snowing, so that's more of a thrill than you think!) I just picked up a pocket Berlitz *Spanish for Travellers*. Thanks to this book, I can now utter the Spanish equivalent of such phrases as "Do you live alone?" and "Can this be invisibly mended?" All I need is a bottle of suntan lotion and I'm all set! Until next month—**Sharon Lowenheim**, Secretary, 303 E. 83 St., Apt. 24F, New York, NY 10028

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I received an impressive press release from Salomon Brothers in New York announcing the promotion of **Larry Hilibrand** from vice-president to director. He is a trader in the Government Trading Department specializing in interest futures and options. Congratulations, Larry! . . . **Dave Plotnik** wrote that he is finally leaving his first job. On March 3 he begins with the Arizona Health Care Loss Containment System (the state medicaid program). He's looking forward to enjoying the sun (I suppose it's a bit better than D.C.—especially in the winter) and Amy's company. They are to be married on June 29 in Nashville. Dave's new home will be Chandler, Ariz.

Ben Teno has had a year of "sweeping changes." He and his wife Pamela had a son (Andrew) in March 1985 and he's returned to school at Wharton. He says that there are 11 other M.I.T. grads in his class, so he wanted to pass along that Wharton welcomes Tech alums. . . .

Chien Huang got married in September and had a great honeymoon through the Canadian Rockies. He's now trying to get out that last great paper—his Ph.D. thesis. . . . From the medical front: **Doris Armour**, **Stephanie Posey**, and **Grace Harrell** all recently graduated from medical school. Doris is in Chicago for a residency in internal medicine. Stephanie will be in Philadelphia and then New York for residencies in internal medicine and anesthesiology. Grace is staying in Boston for her residency in anesthesiology at Mass. General Hospital.

Last but not the least, I've run into **Mitch Gaynor** in the elevator here in Five Cambridge Center. He works downstairs in marketing at Applied Expert Systems, which he joined after graduating from Harvard Business School last June.

Thanks to everyone who wrote this month—**Kate Mulroney**, Secretary, 10 Arizona Terrace #3, Arlington, MA 02174.

81 5th Reunion

I asked **Chuck Markham** to include in our class notes something that would enourage every member of the Class of 1981 to attend our 5th-year reunion this June. I explained that our reunion is going to be the best in M.I.T.'s history—an exotic calypso party, an all-day whale watch, a cocktail party at Endicott House and a delicious Sunday brunch and best of all—an opportunity to catch up with all of our classmates. But, rather than telling Chuck what to write, I decided to write this myself. And, here are some class notes to tide everyone over until the reunion.

Victor Miller is living in Yonkers, N.Y., where he is a systems engineer for Loral Electronics Systems. . . . As for other Victors, **Victor Gilberti** was recently married and is living in Princeton, N.J., where he works for RCA Astro-Electronics designing the NASA space station project. . . . **Joseph Kesselman** wrote to say that he is still with IBM and has been promoted to senior associate engineer. Congratulations!

In the area of M.D.'s, **Nora Fong** has graduated from N.Y.U. Medical School. . . . **Mike Sarin** is enjoying his first year of orthopedic surgery residency at the University of Wisconsin in Madison. . . . **Julie Neuringer** graduated from Brown Medical School in June and is enjoying her residency in Dallas, Texas. In the area of future M.D.'s, **Rich Valicenti** is completing a post-bacc program at Bryn Mawr College prior to entering Hahneman medical school in Philadelphia.

From the land of Procter and Gamble in Cincinnati, Ohio, **Jim Flatt** and **Dave Summa** are enjoying their work in the beauty care and soap bar divisions. . . . **Joe Molitoris** wrote to say that he has completed his Ph.D. in physics from Michigan State University and is currently a fellow of the Alexander von Hombolt Foundation in Frankfurt, Germany, at the Institute of Theoretical Physics. . . . **Tom Semple** received a Ph.D. in chemistry last summer from Brown University. He is currently working on a post-doc at Yale. **Douglas Stamps** received his Ph.D. in mechanical engineering from the University of Michigan last August. . . . **Stephen Probst** is working in the transportation and logistics group at Temple, Barker and Sloane in Lexington, Mass. Stephen and his wife Helen had a son (their first child) on September 20, 1985. Congratulations. . . . **Jeff Solof** and his wife Marta are expecting their first baby in April. Jeff is back at M.I.T. working for the Alumni Fund after finishing a master of divinity degree at St. Vladimir's Orthodox Seminary in New York. Jeff is also co-chairing (with **Mark Chelemer**) our 5th-year reunion gift committee. . . . **Donald Jones** has been named applications engineer for Bellofram Corp.

Steven Costenoble was married to Nancy Banks on July 27th in Garden City, N.Y. Steven received his masters and Ph.D. at the University of Chicago and is currently teaching math and doing research at M.I.T. . . . **James Hancock** is still in Houston, Texas working for Exxon. He's been travelling a lot lately and enjoys seeing other parts of the world.

Darlene Meyer and **Perry Justesen** are living in Ipswich, Mass. They have two boys, Kristjan and Nicholas. . . . **Mark Taylor** is working on his doctorate in biochemistry at the University of Michigan. He claims that he is looking to play in a jazz band. . . . My business school classmate **Dave Noble** is working for McKinsey in Dallas, Texas.

Several of our class officers are living in the Boston area and are working hard to make sure that our 5th-year reunion is fantastic. **Walt Crosby** is with Transportation and Property Systems, **Steve Solnick** is at Harvard pursuing graduate work and **Chuck Markham** is working for Bain and Company. As for myself, I finished my M.B.A. at Harvard Business School last June and shortly after married Ned Lubell, a classmate at H.B.S. I am working in consulting at Bain and Company in Boston. Please keep sending in news for the class notes. I hope to see everyone at our reunion in June.—**Lynn Radlauer Lubell**, Secretary. Please send class notes to: **Chuck Markham**, 362 Commonwealth Ave., Apt. 2E, Boston, MA 02115

Barbara Johnston, '80 (left), M.I.T. Corporation member, and Mike McGraw study plans at the construction site of the Capitol Comfort Inn, a hotel being built by McDevitt and Street Co. in the Chinatown area of Washington, D.C. They work as a team—Johnston as assistant project manager and McGraw as project superintendent.

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Walter Luthinger is still in the navy currently as a weapons officer on the *U.S.S. Gurnard* (SSN-662). Walter has just completed his engineer officer examination and certification at Naval Reactors.—**Rhonda Peck**, Secretary, 11728 Mayfield Ave., No. 4, Los Angeles, CA 90049

83

Hello once again, fellow members of the class of 1983. Since my last column, I was bombarded with a whole stack of letters. I guess it was because everyone was feeling kind of guilty during the Christmas holidays. I appreciate all the letters and cards I received. Let's get on with the news.

Rosa Hernandez wrote a very dramatic note to me. To try and paraphrase it would not do enough justice to her prose, however, I shall try. Rosa was sad at the thought of leaving Cambridge, which explains why she never did. Rosa is currently timesharing between the offices of the American Red Cross for the Cambridge region and M.I.T.'s project Interphase through the office of minority education. Rosa says that she is convinced that the current freshmen have a pretty good chance of making it to graduation. Let's hope you are right! . . . **Don Clayton** indicates that May, 1985 was a very busy month for him. Don graduated from Vanderbilt University with an M.B.A and then eight days later got married to a fellow M.B.A.er. Don's wife is financial ana-

lyst with the Tennessee Public Service Commission, and Don is working for Arthur Anderson's MIS consulting division. Don says that he loves Tennessee. Watch it, Don, that fast pace could kill you! . . . **Ken Segel** sends his best wishes to our class and welcomes all Tech pre-meds to his recently-founded home for wayward techies in Columbus, Ohio. Ken is finishing his third year at Ohio State medical school. Thanks for hospitality, Ken. . . . Marine 1st Lt. **John Roberts** was happy to announce that he has reported for duty with the 3rd Marine Aircraft Wing Camp, in Pendleton, Calif. . . . We also have our representatives in the U.S. Navy. **R. A. Schwarting** writes in that he is working in the Charleston naval shipyard. He recently finished overhauling the *USS William V. Pratt* on which he was a project manager. Mr. Schwarting has qualified as a professional engineer and as a docking officer.

Enough on the military for now. Time to get a bit more international. **Eva Wu** says that she is studying professional acting at the Drama Studio London at Berkeley. She is a member of the fall, 1985 year-long advanced acting program. . . . **James A. Miller** dropped us a line from somewhere in Japan. I guess he was flying off of the aircraft carrier *Midway*. Keg says that he has seen Tokyo, Manila, Persia, Oman, Hong Kong. . . and a few other cities. Like may other globe trotters, James admits that although he is having a wonderful time, he wishes he could share his good fortune. . . . **David Scrimshaw** writes in on the back of a napkin. He is still teaching high school math and raising chickens on the Akwapin Ridge of Ghana. Keeping cool and having fun.

Now, back to Uncle Sam!!! **Michael Lackey** has received his "Wings of Gold." When I first read the note, I thought it was an obituary but I soon realized that these wings meant that Mike has ascertained extensive instruction on airborne radar intercept techniques, air-to-air missile employment and fighter aircraft tactics. Now that Mike has his wings, he was designated a naval flight officer. . . . **Jeanne Straub** was promoted to first lieutenant in the U.S. Air Force. Jeanne is an experimental laser engineer at Kirtland Air Force Base in New Mexico. Jeanne enjoys cooking in her spare time and has taken up riding Harley's with a few of the M.P.'s.

Jude Paganelli has decided that he would rather be a parent than a masters degree candidate at University of California, Berkeley. Jude and his wife Betsy have plans to return to New England by the end of 1986. . . . **Ariana Sarabia** was awarded the Hughes Aircraft fellowship for graduate study. When Ariana was asked what the most important thing in life was, the response was stated, without equivocation, polymers. I think they are too important to Ariana. . . . **Richard Shapiro** has finally announced his engagement to Heather Brooks, the former heart throb of the class of '86. Rich says that Heather was just a sucker for his Ph.D. student in Aero/Astro routine. Rich was hoping to have the ceremony in the engineering library. I hope everything works out! . . . **Duncan Blanchard** has been thinking of dropping out of Infocom, where he is a programmer, to become one of the Hells Angels full-time mechanics. Duncan has not been able to notify the chapter president, as of yet, but is very optimistic.

Many of our classmates have been taking part in the Institute's day-to day operations. **Sarah Bingman** has been appointed as a resource development officer in the school of engineering. Her position will be to help the engineering school's efforts to develop more resources from alumni and industry. . . . **Greg Howland** has been appointed assistant to the treasurer. Greg will be working with the treasurer on the analysis of the Institute's investments and involvement portfolios. . . . **Art Neergaard** has a very interesting view on life. He is currently furthering the American Way in suburban U.S. while trying hard to avoid Marriage, Kids, Wood-Paneled Station Wagons, Eating out at the Ponderosa, Polyester, Discos, A.T.40, *National Enquirer*, Garage Door Openers, In-Sink-erators, and Taxes. Otherwise, he is having a wonderful time and wishes we all were there. . . . **Hans Griesser** finally got married on July 20, 1985, went to Jamaica for the honeymoon, and Boston for a lobster dinner. Hans is now with his wife Marie in Long Beach, Calif., where Marie is a kindergarten teacher and who knows what Hans is doing.

John Lambie married Marsi Thelin on August 10, 1985 in Portland, Oregon. **Renee Robins** and Kris Story, '84 were bridesmaids while Brian Hill, '84, was one of the groomsmen. John is currently working for ERT in Concord, Mass. where he has just recently moved. . . . **Francee Taylor** is attending the University of Washington School of Medicine in Seattle and loves it. . . . **Kevin Johnson** and Sabrina Lewis, '84, were married in October.

Jeffrey Myers is climbing to new heights at Hewlett-Packard logic systems division where he is a marketing engineer. Taking full advantage of the Colorado Springs location, he has climbed 28 of the 54 mountains higher than 14,000 ft. . . .

Robert Norwood, the king of rock & roll in University of Pennsylvania grad school, has joined the band. He is with a local group called the *Clockmen*. In Robert's spare time, he researches linear optics of organic molecular and polymeric structures. . . . Ellen and **Eric Cigan** have announced the birth of a baby girl, Rebecca Elizabeth, who was born on January 20th, 1986. . . . **Hazelyn Patterson** writes in that she needs information on how to order a class ring. This has been the second or third inquiry on how to obtain one. Bill Johnson is our sales representative for Balfour, the company that produces our class ring. They are located in Attleboro, Mass... If you call information and get the number, you will be able to find Bill and order a ring.

I receive mail in strange ways. The other day I was on my terminal and got a message from **Kevin Knadle.** He is currently working for IBM at Endicott and is looking for a job change. He invites other tech graduates who are working for IBM to write to him via PROFS. Kevin's I.D. is KNADLE at ENDVMAS3. And for those of you who need to get me, I am at JEDERUB at NYCVMIC2.

This issue's Celebrity 83 goes to **Jeffrey Harris**. Jeff is currently stationed at the Air Force Weapons Laboratory managing several multi-million dollar programs. He is a member of the New Mexico Educational Council and next year he will be attending the Air Force Institute of Technology graduate program at either Wright Patterson Air Force Base or at M.I.T. With Jeff's busy schedule, he still had time to donate $2,000 to M.I.T.'s endowment. Who said the Celebrity 83 could not be bought? Congratulations on your acceptance to the program and many thanks for your very generous donation.

That about wraps up this issue. As for myself, I am continuing to play games with N.Y. banks and other mortgage institutions. We'll close on this house yet. Keep the letters coming.—**John E. De Rubeis**, Secretary, 47 Gillette Ave., Sayville, NY 11782

85

As commencement nears again I'd like to congratulate all of the '85ers graduating again or after completing degrees (people I can relate to!). Also, I'd like to welcome the class of '86 into the alumni fold. If anyone would like to be considered class of '85 (defectors welcome) be sure to inform the Alumni Association. ALERT! ALERT! Anyone who knows the whereabouts of **Robin Barker** please clue me in. **Alex Menchaca** checked in from Chicago where he is working as a paralegal (prepping for law school). . . . **Stephen Ikeda** is also in the midwest; he is attending Indiana University medical school. . . . I have a special message from **Loretta Miragua**: "I got a job!" She is working in N.Y.C. for Asahi Glass Co.

Several classmates have been commissioned in the U.S. Air Force. **Matt Dorn** graduated from officer training school in Texas. As I understand it, officer training school candidates are carefully selected based on outstanding leadership qualities, so he has received quite an honor. He has been commissioned a second lieutenant and is assigned at Wright Patterson A.F.B. in Ohio. . . . I heard from **Stewart Cobb**. He is also commissioned in the U.S. Air Force and is training to be a space shuttle flight controller on the guidance, navigation, and control (GNC) console in mission control at the NASA Johnson Space Center in Texas. Good luck, Stewart, that should be a challenging job! He claims his next goal is to move up two floors—to the astronaut's offices. Stewart misses M.I.T., but has been in touch since Prof. Dave Akin visited in November when he had an experiment on the shuttle. Like myself Stewart is anxious to know what other Bakerites are up to! He has heard **David Ming** and **Warren Madden** are second lieutenants at Wright Patterson A.F.B., **Rodney Schmidt** is working for Hughes in southern Calif., and **Marian Evatt** is attending medical school at Emory.

Arthur Lee dropped me a line from southern Calif., He claims to have "taken a vow of celibacy" while he is a grad student at Cal Tech . . . perhaps that's a bit extreme, Arthur! He works on a molecular beam machine studying surface-particle interactions in the chemical engineering department. At Cal Tech he says that they fantasize that "M.I.T. is a division of Cal Tech," absolute blasphemy! Some of you may remember Arthur from his sports reports in *The Tech*. He is curious about how some of our stellar atheletes are—**Patrice Parris** and **Greg Procopio**, to name a couple. **Mitch Messer**, of fencing fame is employed by AT&T in New Jersey. **Marty Dichau** and **Gee Ng** are working for Digital Equipment Corp. Marty is in Nashua, N.H., and Gee is in Hudson, Mass. Mitch, Gee, Marty, **Bob Andreotti**, and Arthur were all F-Entry Vigilantes in Mac Gregor. Bob is in Texas working for General Dynamics. Arthur also updated me on his friends from Burton five. **Tom Foo** is pursuing a Ph.D. in chemistry at Berkeley where he is breaking a lot of girls' hearts—eleborate on that one please, Arthur. **Albert Wang** is also at Berkeley studying chemical engineering. **Kevin Lam** is in Connecticut working for The Hartford insurance firm. And, **Joe Braddock** is working for Biogen before he attends medical school. Arthur ran into **Greg Wanish** (next house) in Pasadena where Greg works for Burroughs Computer. And, wrapping up the Burton house crowd, **Josh Kaplan** is bumming around his hometown—N.Y.C. where **Kentaro Horiuchi** is also, attending Albert Einstein medical school.

Tom and Albert are by no means alone at Berkeley. **Dan Crean** is there contemplating the correlation between baldness and being a graduate student. He wrote a column in *The Tech* on that very topic, elaborating on life at Berkeley: "Almost any weekday (radicals go to Tahoe on the weekends) you can go down to Sproul Plaza, the center of campus, at lunchtime, and if they're not having a mini-revolution there are numerous believers proselytizing everyone in earshot. This gives the university an added dimension which M.I.T. never really had, because even though every M.I.T. student thinks he or she knows everything, none of them have the courage to make fools of themselves in public." Don't worry Dan, from what I have seen this term, M.I.T. hasn't changed in that respect! I'll have to check out the spectacle at Berkeley when I return to California! Until next issue . . . (note my new *permanent* address)—**Stephanie Scheidler**, Secretary, 3511 Shafer Dr., Santa Clara, CA 95051

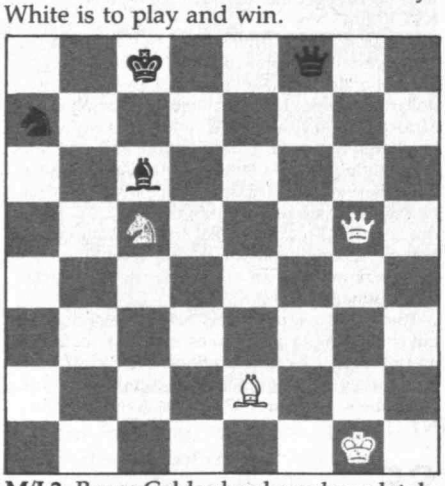
ALLAN J. GOTTLIEB

Thoughts While Shopping in a Favorite Supermarket

For the information of newcomers, here are the criteria I use to select solutions for publication. As responses to problems arrive, they are sorted by problem, with no regard to their date of arrival or postmark. When it is time for me to write the column in which solutions are to appear, I first weed out erroneous and illegible responses. For difficult problems, this may be enough; the most publishable solution becomes obvious. Usually, however, many responses remain. I next try to select a solution that supplies an appropriate amount of detail and that includes a minimal number of characters that are hard to set in type. A particularly elegant solution is, of course, preferred. I favor solutions from correspondents whose work has not previously appeared, as well as solutions that are neatly written or typed, since the latter produce fewer typesetting errors.

Problems

M/J 1. We begin with a chess problem that Bob Kimble attributes to Seletsky. White is to play and win.



M/J 2. Bruce Calder has been busy lately bouncing BBs on top of superballs:
A BB 2 mm. in diameter sits atop a "Superball" 10 cm. in diameter, the center of which is 1 meter above the ground. If both objects are released simultaneously, what is the maximum possible height the BB can attain upon rebound?

M/J 3. The following problem is from John Rule:
From the front to the rear of an advancing army detachment was 10 miles. A rear guard messenger, dispatched to the guard house directly behind his position in the line of march, returned without loss of time and then proceeded immediately to the vanguard and again returned. He then noted that he had overtaken his guard 10 miles from the starting point and that the time spent on each errand had been the same. How far was the guard house from the starting point, and how far did the messenger travel altogether?

M/J 4. Phelps Meaker, whose eyes are 62 inches above the ground, notes that the floor of the aisles in his favorite supermarket is glossy linoleum and reflects the fluorescent lamps installed crosswise to the aisle 10 feet above it. As he moves down the aisle at a uniform rate of 42 inches per second, the reflected images move as well. When a lamp is a horizontal distance D ahead of him, what is the speed of its image in the floor?

M/J 5. Our last regular problem is from Nob Yoshigahara via Richard Hess:
Fill in the boxes with the digits 0, 1, 2 . . . 9.

$$\square\square^{\text{min}}:\square\square^{\text{sec}} \times \square = \square^{\text{hrs}}:\square\square^{\text{min}}:\square\square^{\text{sec}}$$

Speed Department

SD 1. Our first speed problem appeared in *The Tech*, M.I.T.'s student newspaper, as part of the "Freshman Quiz": Translate the following into a limerick:

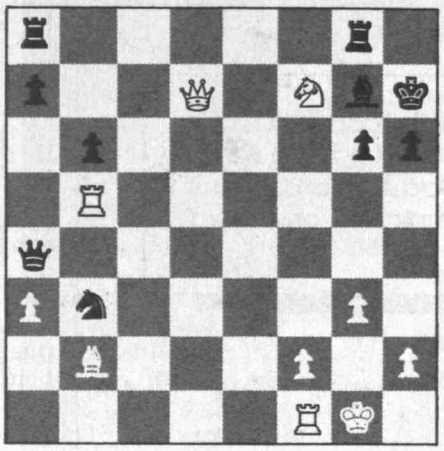
$$\int_i^{3\sqrt{3}} z^2 dz(\cos 3\pi/9) = \ln e^{1/3}$$

SEND PROBLEMS, SOLUTIONS, AND COMMENTS TO ALLAN J. GOTTLIEB, '67, THE COURANT INSTITUTE, NEW YORK UNIVERSITY, 251 MERCER ST., NEW YORK, N.Y. 10012.

SD 2. The 1986 M.I.T. Integration Bee included the following problem:
$\int \{[\sin(x) + \cos(x)]dx/\sqrt{1 + \sin(2x)}\}$

Solutions

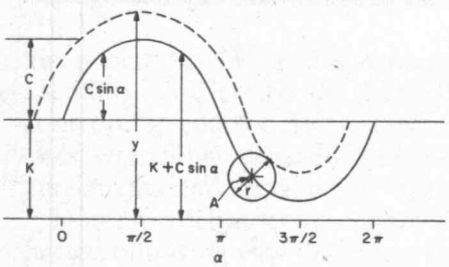
JAN 1. White to move and mate in four.



Robert Bart, Stephen Callaghan, and Matthew Fountain have refuted this problem by showing that with best play mate requires five moves, not four. The key move for White is R-h5, but Black answers with Q-f4 and after PxQ replies N-d4. Now the quickest mate is RxP, BxR, N-g5, K-h8, Q-h7.

Also solved by Erwin Bramhall, Paul Tesser, Ted Clampitt, Albert Moore, Richard Hess, Steve Feldman, Ray Kingsley, Greg Spradlin, Ron Raines, and Matthew Ek.

JAN 2. Philip Hogin offered $100 for a solution to
$y = f(\alpha)$
for given values of K, C, and r in the diagram below.



For some reason this problem attracted considerable attention. Could it have been the $100 reward? To be fair, I waited until today, 21 March, the closing date for the column, to gather together all proposed solutions and send them to Mr. Hogan for his decision (and disbursement). As soon as I hear, I will announce the lucky winner.

Responses were received from Ali Nadim and Hossein Haj Hariri, Matthew Ek, Richard Garner, Tom Tiller, Bruce Calder, Daniel Morgan, David Leblang, David Meyer, Dean Peterson, Jahir Pabon, Marc LaBranche, Martin Carrera, Matthew Stenzel, Mengli Du, Robert Moeser, Matthew Fountain, Richard Hess, Bin Ly, Harry Zaremba, Albert Moore, A. Lawson, Dennis Brown, Shahriar Negahdaripour, Winslow Hartford, Norman Wickstrand, Frank Quinn, Bill Peak, Ray Kingsley, William Messner, and Charles Benesh.

JAN 3. The six-digit number 142857 has interesting properties: one times the number is 142857; two times is 285714; three times is 428571; four times is 571428; five times is 714285; and six times is 851428. All these products are rotated versions of the original. Are there other numbers having the property that multiplication by any positive integer not exceeding the number of digits in the original number produces rotated versions of the original?

The following solution is from Robert Moeser:

I recognized 142857 as an integer made from the repeating part of the division 1/7. In fact, any prime that exhibits a repeating decimal of the full theoretically possible length (p − 1 for a prime p, since all numbers except p itself and zero appear as remainders) will have the desired properties. Seventeen for example, and I checked that out. There is no way of telling in advance whether a prime will have a maximum-length repeating decimal, but those that do can be used to produce the interesting numbers. Do the division (let a computer help you, please!) and then make the repeating part into an integer. Viola! In essence, multiplying such a number by any positive integer less than the prime used to produce it is just like starting a division process that is bound to repeat itself, but has the effect of shifting the repeating digits over to the point (in the division 1/p) where the number appears as a remainder. The following remainders follow the same cycle, which of course leads eventually back to a remainder of one, and then sooner or later again to the number used as a multiplier. The net result is the same digits appearing in the quotient, only rotated!

With his solution, Matthew Fountain included the related remark that as a boy he saw a magician multiply a large number by 142857 in his head. Later Mr. Fountain realized that the magician had divided by 7 and made a correction. However it must be noted that while doing this the magician was also writing upside down and backwards and memorizing cards read to him.

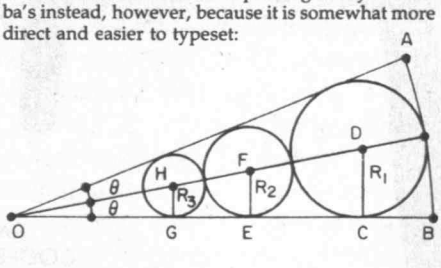
Also solved by Sidney Darlington, Eli Passow, Avi Ornstein, Edward Lynch, Winslow Hartford, Bin Ly, Richard Hess, and Naomi Markovitz.

JAN 4. Given the sector OAB of a circle of a unit radius with angle 2θ. For what θ is the ratio of the sum of the three inscribed circles' areas to the sector's area largest, and what is its value?

I received the following note from Jason Bitsky, which I feel is too good not to share:

I've been convinced for some time that, having been a corporate lawyer in New York for this long, my cognitive faculties have long since atrophied. As I'm sure you know if you've ever encountered one, every good lawyer faithfully commits himself to the ideal of rarely thinking intelligently about anything and certainly not if there's no bucks to be made. This being my normal state, I generally limit my exposure to *Technology Review* to a brief glance at a few of the more dramatic color graphics. But, as I flipped through the pages this time, problem **JAN4** in "Puzzle Corner" caught my eye. It reminded me of the kind of computational exercise that entertained me often in the precatatonic phase of my life. Anyway, I decided to look brain death straight in the face and try my hand at the problem. Like an antique engine, rusty cogs began to turn, trigonometric identities flickered up out of the mental morass, and a long-moribund intellect, briefly revived, produced the following answer. I doubt very much that it is the simplest, most direct solution, but I hope it will not embarrass me.

Mr. Bitsky has not embarrassed himself; indeed his solution is correct. I am printing Harry Zaremba's instead, however, because it is somewhat more direct and easier to typeset:



Since the radius OA = 1, the area of sector AOB is
$A_s = OA^2/2 \times 2\theta = \theta$.
From triangle OCD, $R_1 = OD \times \sin\theta$, or
$R_1 = (1 - R_1) \times \sin\theta$,
from which $R_1 = k$ where $k = (\sin\theta)/(\sin\theta + 1)$.
From triangle OEF, $R_2 = OF \times \sin\theta = (1 - 2R_1 - R_2)\sin\theta$, or
$R_2 = k(1 - 2K)$.
In a similar manner from triangle OGH,
$R_3 = k(1 - 2k)^2$ and for the ith circle,
$R_i = k(1 - 2k)^{(i-1)}$.
The area of the circles where $i \to \infty 1$ is
$A_c = \pi(R_1^2 + R_2^2 + R_3^2 + \ldots + R_i^2 + \ldots)$
$= \pi k^2 [1 + (1 - 2k)^2 + (1 - 2k)^4 + \ldots + (1 - 2k)^{2(i-1)} + \ldots]$
$= \pi k^2/[1 - (1 - 2k)^2]$
$= \pi k/[4(1 - k)]$.
Substituting for k and simplifying,
$A_c = \pi \sin\theta/4$.
The ratio of the sum of the circle areas to the area of the sector is
$R = \pi/4 \times (\sin\theta)/\theta$.
Maximum R occurs when θ approaches zero, for which $(\sin\theta)/\theta \to 1$. Thus,
$R_{max} = \pi/4 = 0.785398$.

Also solved by Dave Mohr, Michael Jung, Thomas Compton, Naomi Moskovitz, Matthew Fountain, Richard Hess, Bin Ly, Winslow Hartford, Steve Feldman, Norman Wickstrand, Harry Zaremba, Jason Bitsky, Stephen Scheinberg, Eli Passow, Norman Spencer, and the proposer, Howard Stern.

Better Late Than Never

1985 JUL 4. Phelps Meaker notes that it was John Rule and not he who proposed this problem. Moreover, P.V. Heftler and Steve Feldman noticed that we mistakenly published the solution for A/S 4 instead. Fortunately, my records proved adequate in this case, and here is the correct problem:

A manufacturer makes all possible sizes of brick−shaped blocks such that the lengths of the edges are integral multiples of the unit of length, and that the number of units in the total of twelve edges of the block is equal to two−thirds of the number of units of volume in the block. What sizes does he make?

Furthermore, here is the correct solution submitted by Avi Ornstein last June:
$4(A+B+C) = 2(A \times B \times C)/3$
$6(A+B+C) = (A \times B \times C)$
$6(A+B) = (A \times B \times C) - 6C$
$C = 6(A+B)/(A \times B - 6)$
Since the answers must all be integers, I let A and B be the two smallest sides of each brick. Acceptable solutions were found when $A \times B = 7, 8, 9$, or 12. I found that the bricks are made in eight different sizes: (1,7,48), (1,8,27), (1,9,20), (1,12,13), (2,4,18), (2,6,8), (3,3,12), and (3,4,7.)

1985 N/D 2. Joseph Feil has responded.

1985 N/D 5. Gerald Leibowitz reports that related questions have been studied in the literature.

Y1985. The following improvements come from Robert Deutsch, Gregory Daley, Tom Harriman, and Steve Feldman.
$2 = 9+8-15$
$11 = 9+8-5-1$
$28 = 1+9\times(8-5)$
$39 = 58-19$
$41 = 59-18$
$93 = 1\times98-5$
$95 = 1+9+85$
The original solution $11 = -1 + 9 + 8 - 5$ would be preferred if the initial minus is not considered an operator but part of the number minus one.

JAN SD2. Ruth Cross would prefer that the last line be given as, "Is nine times itself and no more." Charles Bostick notes that this problem appeared in a 1969 issue of *Word Ways*, a journal of recreational linguistics.

Proposer's Solutions to Speed Problems

SD 1. "Integral z-squared-dz,
From one to the cube root of three,
Times the cosine of three
times pi over nine,
equals ln-of-cube-root-of-e."

SD 2. x + C (play with the denominator). □

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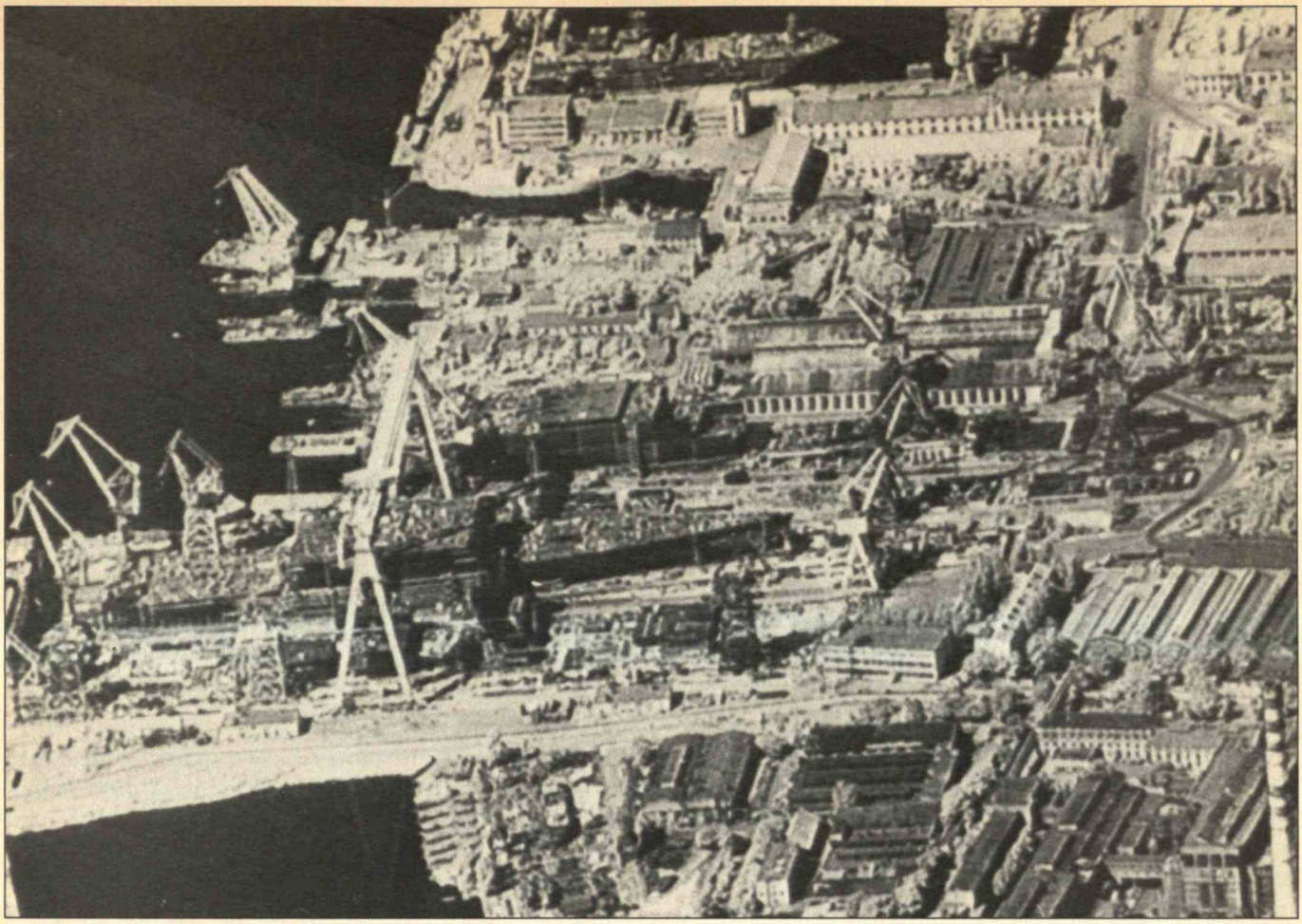

This computer-enhanced satellite photo, published in 1984 in *Jane's Defence Weekly*, shows a Soviet aircraft carrier under construction on the Black Sea. Photo reconnaissance produces such detailed images to help verify arms treaties.

viet violations helps to stimulate domestic defense spending and lessens the likelihood of new arms-control agreements. Soviet misbehavior also stimulates wrenching debates over the value of existing agreements and appropriate U.S. responses.

Domestic debates over Soviet compliance have reflected opposing viewpoints comparable to those on verification. When President Kennedy pressed for the Limited Test Ban Treaty, he was in a strong political position to defuse the compliance issue, because he had recently demonstrated his toughness with Moscow. A moratorium on atmospheric testing had been in place since 1958, but after France and then the Soviet Union had broken it, Kennedy swallowed his reservations and followed suit in 1961. If the Kremlin reneged on the Test Ban Treaty, few doubted that he would respond in the same way.

During congressional review of the SALT I accords, President Nixon's reputation as a staunch anti-communist deflected concerns over possible Soviet noncompliance. Moreover, he was committed to proceeding with the B-1 bomber, the Trident submarine, new cruise-missile programs, and other initiatives that would strengthen the U.S. hand in subsequent negotiations. Furthermore, the SALT I accords established the Standing Consultative Commission (SCC), a U.S.-Soviet forum that would meet each spring and fall in Geneva to resolve whatever compliance questions might arise.

Compliance questions did arise. Supporters of the SALT process believed that the problems simply reflected the inability of any agreement to cover every contingency. Critics believed the problems reflected concerted Soviet efforts to secure unfair advantages. In 1978 the Carter administration released an unclassified report describing how the SCC had handled compliance questions. The report did not dispute that the Kremlin had occasionally exploited ambiguities in the SALT I accords. But the administration concluded that whenever the United States had raised a troublesome Soviet practice at the SCC, "the activity had ceased or subsequent information had clarified the situation and allayed our concern."

Soviet tests of the SA-5 air-defense radar provide an illustration of how the SCC handled treaty encroachments during the Nixon, Ford, and Carter administrations. Article VI of the ABM Treaty bars testing air-defense radars "in an ABM mode" to prevent them from being incorporated into ballistic-

PHOTO: AP/WIDE WORLD

The Soviet radar tests stopped three weeks after the U.S. questioned their legality.

missile defenses. However, the superpowers could not agree on what constituted tests "in an ABM mode." Moreover, the United States had insisted that air-defense radars might be turned on in unusual circumstances during missile tests if operators were concerned about safety at the test range.

In 1973 U.S. intelligence analysts began to notice that the Soviets were turning on a radar, which was eventually identified as part of the SA-5 air-defense system, while missile tests were in progress at the Sary Shagan test range. When, after extensive analysis, the Ford administration became convinced that the radar tests raised questions about Soviet compliance, the United States raised the issue in the SCC. The tests stopped within three weeks. After two years of private diplomacy, the Carter administration worked out an agreement with the Soviets on allowable tests of air-defense radars.

Supporters of the SALT process and the SCC considered the case of the SA-5 radar a success story. Nixon, Ford, and Carter administration officials assumed that the tests at the Sary Shagan range would do little to help Soviet air-defense crews target strategic U.S. ballistic missiles, and the Defense Department did not request funds to improve the ability of U.S. missiles to penetrate Soviet defenses. Today few strategic analysts suggest that the SA-5 system has ballistic missile-defense capabilities.

Presidents Nixon, Ford, and Carter avoided a prosecutorial approach in dealing with questionable Soviet practices. Instead, they contained problems by working out agreements clarifying ambiguous treaty provisions. They sought to reaffirm the ABM Treaty and to halt Soviet activities that could undermine the accord over time. Critics of the SALT process led by Secretary of Defense Weinberger and his arms-control advisor, Richard Perle reject this analysis and question the wisdom of reaffirming the ABM treaty. They assert that the Kremlin gained unfair military advantages by exploiting treaty provisions, that Soviet violations were merely grandfathered into the SCC's "solutions," and that the United States should proceed with SDI in lieu of the treaty.

The Current Impasse

Compliance controversies took on an entirely different cast in recent years. The Soviets' record of compliance progressively deteriorated in the last few years of the Brezhnev era. The Reagan administration responded by adopting new tactics, reflecting official displeasure with past agreements, dissatisfaction with the record of Soviet compliance, and a keen interest in "public" diplomacy. Rather than attempting to solve problems in the SCC, administration officials led the chorus in denouncing Soviet violations.

At the outset, Pentagon and Arms Control and Disarmament Agency (ACDA) officials in the Reagan administration argued against raising SALT II compliance questions in the SCC. They did not want to give credence to an agreement whose ratification they had helped block during the Carter administration. Instead, the administration directed the U.S. delegation to express concern over SALT II compliance without engaging in a dialogue on how to resolve problems. Then in 1983 two major compliance flaps occurred. In February the Soviet Union began flight testing a second new ICBM, offering a strained explanation that it was merely a permitted modification of an existing type. The Reagan administration raised this issue during the spring session of the SCC. In the summer, the United States identified the Krasnoyarsk radar, some two years after construction had begun. The SCC discussed it that fall.

Reagan administration officials quickly presumed that both the new missile and the radar were serious violations and demanded that the Soviets cease their activities and tear down the radar. They further judged that Moscow's concerns over U.S. radar construction were frivolous and just a smoke screen to cover Soviet malpractices. There was no clear remedy for the new missile, since some officials considered this violation "irreversible": now that the Kremlin had tested and begun to produce the missiles, they could be illegally hidden.

The year 1983 was a politically volatile one for U.S.-Soviet relations, capped by the deployment of NATO intermediate-range missiles and the Soviets' walk-out at Geneva. Extended negotiations to resolve these compliance problems were not feasible in this heated political environment. When the Kremlin declined to plead guilty as charged in the SCC, the White House publicized its grievances, responding to a congressional request engineered by treaty critics. The administration has subsequently issued annual reports of Soviet noncompliance.

These reports mix substantive compliance problems, such as the Krasnoyarsk radar, new missile types, and Soviet encryption, with trivial matters

such as the Soviet "violation" of the Limited Test Ban Treaty due to the release of radioactive debris from underground tests. The United States has had similar problems with "venting" at the Nevada test site, but not as often. Modest issues that prior administrations would have resolved in the SCC, such as the status of obsolete Soviet bombers, appear on the same list with serious charges—such as the allegation that the Soviets and their allies used mycotoxins ("yellow rain") in Southeast Asia, for which there have been no confirmed reports over the past three years. The administration also asserts Soviet violations in highly ambiguous cases. For example, it insists upon Moscow's "probable" violation of the unratified Threshold Test Ban Treaty, which limits the yield of underground nuclear-test explosions to 150 kilotons. Three separate Department of Defense reviews in 1985 failed to confirm this charge.

Fully half the citations of Soviet violations relate to agreements that the Reagan administration refuses to ratify. The overall picture of Soviet compliance practices is further skewed because administration reports have failed to detail those instances in which the Soviets are unquestionably complying with agreements. Reading these reports, one would never know that since 1972, the Kremlin has dismantled or mothballed more than 1,200 missiles in deference to SALT ceilings.

Mobile missiles such as the Soviet SS-20 (above) and SS-25 (right) pose verification problems that require political cooperation. So far, the Kremlin has deployed these missiles in observable patterns, but if it deploys them in irregular ways, they will be hard to count.

Despite all their weaknesses, administration reports have had serious political repercussions. Future arms-control agreements will have to meet stricter standards for verification and compliance because of the substantive problems documented and the salience given them by senior Reagan administration officials. Furthermore, these higher standards will be applied to weapons such as mobile and cruise missiles that are difficult to count once deployed.

Restoring Cooperation

Today's controversies over arms-control verification and compliance have much in common with prior disputes. One analyst's essential verification requirements are another's formula for failure in negotia-

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Monitoring technologies and on-site inspections cannot fulfill the expectations many have for them.

tions. Likewise, whether a particular action is a clear-cut violation or a grey-area exploitation depends on whose ox is being gored. Conclusions tend to be maddeningly immune from technical considerations, depending instead on basic assumptions about the value of nuclear arms-control agreements with the Soviet Union.

The favored instruments of both skeptics and supporters of new agreements—on-site inspections and advanced monitoring techniques—can provide substantive as well as political support for new agreements. For instance, inspections of nuclear power reactors have been indispensable in monitoring the 1968 Non-Proliferation Treaty, whose signatories have pledged not to divert reactor products for making bombs. And inspections could help verify compliance with a low-threshold or comprehensive test-ban on nuclear weapons by confirming the absence of radioactive debris around the geographical coordinates of a suspicious event. The right to conduct inspections could not only help deter cheating but build congressional and public support for new treaties. Soviet leader Mikhail Gorbachev has hinted that the Soviets would be receptive to test-ban inspections, but only if the United States is prepared to sign new agreements and ratify old ones.

Advances in monitoring technologies can also do a great deal to restore public confidence in arms control. Placing new sensors in space to monitor the use of directed-energy devices such as lasers could help reaffirm the 1972 ABM Treaty and facilitate negotiations for an ASAT accord. And the prospects for monitoring a comprehensive test-ban agreement have been markedly enhanced by new monitoring techniques keyed to high-frequency seismic signals. Technical disputes no longer center on whether regional seismic networks can detect underground explosions of one kiloton or less, or whether those networks can distinguish between earthquakes and low-yield underground tests. Now the questions have to do with the number and placement of seismic stations needed to accomplish these feats.

However, on-site inspections and new monitoring technologies cannot fulfill the expectations that many people have for them. Even the most advanced monitoring technologies have inherent limitations. For example, monitoring devices are of limited use for cruise missiles that can be converted from conventional to nuclear versions because of their modular design. Mobile missiles—such as the Soviet SS-20 and U.S. Pershing II intermediate-range missiles, or the Soviet SS-25 and the proposed U.S. Midgetman ICBMs—can be monitored as long as they continue to be deployed in observable patterns. If deployed in irregular ways, however, they will be difficult to count. Moreover, even if advanced technologies could track mobile missiles continuously, they would defeat the purpose of mobility: assuring that these weapons could survive a surprise attack. Ironically, this monitoring technology would be destabilizing.

On-site inspections also have limitations. For instance, inspectors might be able to count a ship's nuclear-armed cruise missiles, but ships can be resupplied with more at sea. On-site inspections will not reveal much about mobile missiles that might be hidden from inspectors and subsequently deployed.

Even an open society such as the United States is unlikely to allow thorough inspection of all relevant facilities, including top-secret military plants, and no country is likely to grant an inspection that uncovers a "smoking gun." Inspections may not prove compliance either: they may be inconclusive, or they may raise additional concerns by producing ambiguous evidence.

Only cooperative political arrangements can provide a way out of these dilemmas. Indeed, recent weapons developments make the need for cooperative verification greater than ever before. Consider the case of mobile intercontinental or intermediate-range ballistic missiles. If the United States and the Soviet Union want to limit their numbers, both have a stake in basing them in ways that ease verification problems. For example, these missiles could be deployed only on designated reservations. Such reservations would be large enough to frustrate an attack but small enough to facilitate observation by photo-reconnaissance satellites. Access routes into the reservations could serve as check points, where seismic sensors could help the opponent track the missiles entering and leaving.

Another way to monitor weapons such as cruise and mobile missiles that are difficult to count once deployed is to establish schemes for monitoring production. Both sides already monitor weapons factories by national technical means, particularly photo-reconnaissance satellites. They could reinforce this coverage by agreeing, for example, to provide data on monthly production rates and the

In 1979 Sen. John Glenn (D-Ohio) voiced concerns as to whether SALT II was verifiable and cast a symbolically important vote against the treaty in the Senate Foreign Relations Committee. In the end the treaty was never ratified.

locations of plants producing distinctive, critical components, such as solid-fuel rocket motors for mobile missiles. Cooperative measures could allow each side to confirm the data by placing tamper-resistant sensors—cameras, short-range radars, infrared sensors, or seismic detectors—around declared factories. These factories already have secure perimeters; sensors most appropriate to the items being produced could confirm that perimeter's integrity for both observer and owner, while counting the units that leave the factory gates. Both sides could have equal access to whatever information the devices might provide. Opinions vary as to how elaborate and expensive production-monitoring schemes must be.

Despite their great promise, cooperative measures also have their limitations. Some, such as those dealing with production monitoring, will be difficult to negotiate, though they are more feasible than provisions for thorough on-site inspections of top-secret military plants. More important, cooperation can be withheld once agreements are in force, raising serious monitoring problems. Cooperative measures may also uncover ambiguities that may be resolved through diplomatic channels or may be labeled as violations. In the final analysis, no verification scheme can work if either side decides to withhold cooperation. Heavy reliance on cooperative measures merely makes this political fact of life more explicit.

For the past five years the United States and the Soviet Union have made little political progress in verification and compliance issues. They have not begun to negotiate cooperative measures needed to help monitor deployments of mobile and cruise missiles. In the strategic-arms talks, the administration proposes to ban mobile missiles, ostensibly because they are unverifiable, yet in the talks on intermediate-range missiles, the Reagan administration proposes ways to monitor reductions of mobile SS-20 missiles. Meanwhile, the Kremlin plays a waiting game, deploying new mobile systems in ways that allow the United States to keep an accurate count, but declining to initiate discussions on formalizing these deployment practices. Efforts to pursue cooperative agreements necessary for ASAT limitations and a nuclear test-ban remain stalled by the Reagan administration's interest in developing new weapons rather than negotiating new agreements.

At the same time, substantive compliance problems continue to fester. The administration repeats its bill of particulars on Soviet noncompliance and demands action to alleviate its concerns. However, it declines to pursue "alternative resolutions" in the SCC—bureaucratic code for entering into negotiations with the Soviets to resolve compliance disputes. Neither the State Department nor ACDA strongly supports such negotiations, and the Pentagon is implacably opposed. For its part, the Kremlin drops hints that it is now more open toward verification and ready to make a deal on the Krasnoyarsk radar, but genuine breakthroughs appear tied to a relaxation of the Reagan administration's unyielding positions on the comprehensive test ban and SDI.

As long as this impasse exists, realistic solutions to onerous verification and compliance problems—and realistic negotiations on key arms-control agreements—will have to wait. Whoever wins the presidency in 1988 will have great difficulty cleaning up the enormous mess that the Kremlin and the Reagan administration have created. □

PHOTO: AP/WIDE WORLD

The new science of building diagnostics merges design specialties to improve the health of structures and the people inside them.

DOCTORS FOR BUILDING

BY FORREST WILSON

To Hugh Miller, diagnosis is a sensual exercise. He first examines his patient for visible symptoms of decay. He sniffs for musty odors that disclose moisture levels approaching the danger point. He feels surfaces for gross textural distortions. The touch of the powder left by insects discloses the presence of termites or wood-boring beetles; a careful fingering of it tells him the species. He taps beams and struts, listening for soundness. Miller uses a stethoscope to hear carpenter ants busily chewing a timber. He tongues suspicious encrustations to detect salts, but does this very gingerly, for some of them are toxic.

Hugh Miller is a practitioner of "building diagnostics," an emerging science whose goal is to predict the future performance of both historic and new structures. Building diagnostics depends on human beings both as the measure of environmental well-being and the sensors of building malfunctions. This focus erases the distinctions between the "soft" social sciences and "hard" physical sciences.

Miller specializes in analyzing historic buildings. As chief historical architect for the U.S. Parks Department, he has under his care buildings entrusted to the National Parks Service. His examination of them begins with a walk around, through, and then back again through the open spaces of each. He surveys the building's exterior for significant danger signs, especially those that suggest moisture, the worst enemy of materials. Since the roof is the chief defense against moisture, it is key to the survey. Miller photographs areas to be looked at with special care and writes notations on the photos. He examines both the roof and everything on it—the chimneys, stacks, cupolas, ornaments, and lightning rods that, to him, constitute a single system.

Next he inspects walls for bulges and sags that reveal structural problems. He scrutinizes surfaces for the growth of moss and algae, which show moisture is creeping through. He studies the place where the building touches the ground, since this is the launch pad for dampness, salts, and building-eating insects.

The 400,000 pieces of terra cotta on the Woolworth Building (above) began to deteriorate faster than they could be replaced. Building diagnosticians (left) found ways to restore them.

PHOTOS: WJE/USG CORP.; FORREST WILSON

Miller makes a number of visits, including at least one when it is raining hard enough to show him how the building takes water and how the nearby ground drains water away. To find out how walls are built and timbers fastened, he uses non-intrusive testing methods such as x-rays, which are effective, but not damaging. Ultrasonic instruments measure strength and detect irregularities in concrete, wood, and masonry by recording how high-frequency waves pass through or are deflected. Strain gauges attached to the structure record microscopic movements that tell whether cracks are growing. Fiber-optic instruments, with or without cameras attached, peer into remote cavities or pipes, or into small holes drilled through surfaces. When it's necessary, Miller takes cores or other samples to a laboratory for tests to determine the presence and density of moisture.

Examinations take about a week, and Miller returns to the building several times to see how it changes over time. Usually he takes precise measurements periodically and compares them. He measures the building's movements with simple "tell-tales"—thin glass sheets that break when the building moves or strips of plastic calibrated to indicate deviations from normal. Also plunger-type micrometers fixed across cracks record every movement of the building. If instruments can be attached to recording devices, they document time-related trends such as crack growth.

No matter what instruments Miller uses, his five senses guide and inform him. He has honed these over 20 years in the restoration of historic buildings. Like a diagnosing physician, Miller bases his prognoses on professional judgment. He is himself a diagnostic device.

This historical architect is a prime illustration of building diagnostics' reliance on human beings as sensors of malfunctions. The infant science can perhaps best be understood in the context of the failures that dramatize the need for it.

The Symptoms

On July 17, 1981, two suspended walkways in the atrium of the Kansas City Hyatt Regency Hotel collapsed, killing 113 people and injuring 186. It was perhaps the most devastating disaster of its kind in American history.

FORREST WILSON is a professor of architecture at Catholic University of America in Washington, D.C.

On June 28, 1983, a 100-foot-long, diamond-shaped section of the bridge on I-95 in Connecticut suddenly plummeted 70 feet into the Mianus River. Three people died. The bridge, constructed in the mid-1950s, had been inspected and declared safe nine months earlier.

For those who design and construct buildings, among the most embarrassing failures occurred on June 4, 1979, when the roof of Kansas City's 17,000-seat Kemper Arena collapsed. Fortunately the building was empty and no one was hurt. Five years earlier the American Institute of Architects (AIA) had given the Kemper Arena its highest award; when the roof collapsed, the AIA was holding its annual convention a few blocks away.

Some of the most famous buildings of the best-known architects and engineers have earned similar notoriety because of malfunctioning interior environments. One such structure is the Gregory Bateson State Office Building in Sacramento, Calif., designed by the Office of the California State Architects. The workers inside were plagued by respiratory, gastrointestinal, skin, and eye problems from its opening in 1982. Some have suffered dizziness, loss of balance, occasional sore throats, and itchy skin.

We do not build buildings as we once did, nor do they fail as they did before. Modern failures can be attributed to several causes. The professions and vocations in the building design and delivery process have become fragmented, and professional academic preparation is lacking. In addition, both old and new building materials and structural systems deteriorate, and contemporary work environments present unique dangers.

Who's Responsible?

Much like the Civil War 80 years earlier, World War II brought a significant change in the materials and methods of construction and in the organization of commercial and industrial enterprise. Architectural and construction engineering firms began to pattern themselves after the institutions they served, compartmentalizing activities to imitate industrial divisions of labor. Conceptual design and the design of plumbing, windows, interiors, and mechanical systems went to specialists; in the fall of 1880 Frederick Winslow Taylor had achieved a similar effect by reducing the skills of master mechanics at the Midvale Steel Company to a succession of simple tasks.

ALL CONTACT SHEET PHOTOS BY FORREST WILSON

Building diagnosticians use their senses to understand the process of deterioration. Instruments extend the senses, helping to measure the minute movement of cracks and detect the presence of moisture below surfaces.

In the mid-1960s Princeton University professors Bernard Spring and William Geddes, with funding from the AIA, identified almost 250 different design specialties.

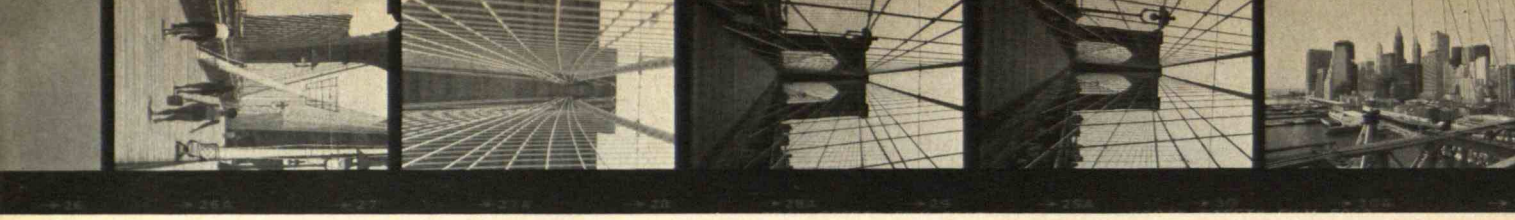
Today the design profession includes specification writers, space planners, construction detailers, interior designers, interior decorators, and landscape designers. There are electrical engineers, lighting engineers, acoustical engineers, heating engineers, cooling engineers, ventilation engineers, and "human factors" engineers. Newcomers to the list are psychologists and environmental psychologists, ecologists, ergonomists, industrial designers, phenomenologists, psychophysicists, and anthropologists.

One victim of specialization is accountability, as the Hyatt Regency disaster demonstrated. According to the National Bureau of Standards, a connection between a threaded rod and a beam supporting the walkways failed. Although a general contractor, a construction manager, a testing and inspection laboratory, an architect's resident inspector, and city inspectors were responsible for construction quality, apparently no one noticed—or even suspected—the obviously faulty connection.

Lev Zetlin, a building diagnostician and internationally known design engineer, investigated the tragedy. His firm surveyed building literature extensively to determine how both design professionals and the construction industry defined responsibility. The review covered government documents, building codes, semi-official and official publications serving practicing architects and engineers, and the books describing the function of building vocations and disciplines.

Zetlin's team found that textbooks delegated responsibility one way, steel-design handbooks another. Standard documents for architects, engineers, and construction managers all serve their own professions; consequently, they delegate responsibility differently, too. It was, Zetlin remarked, "open season on responsibility." He concluded that both no one and everyone was responsible for the Hyatt Regency disaster. The courts, forced to assign the blame, placed it on the engineers.

PHOTOS: HUGH MILLER



Newer Is Not Always Better

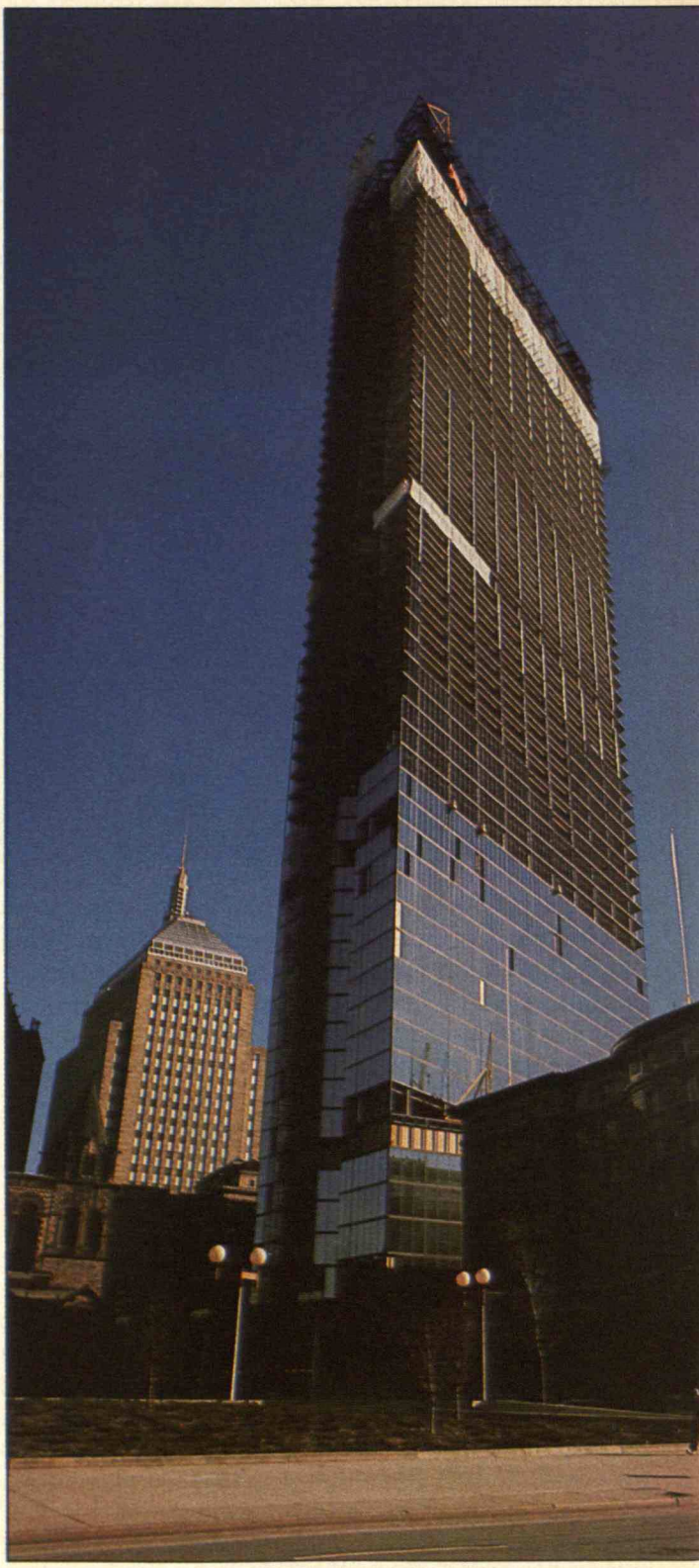
John M. Hanson identifies a second cause of building failures: inadequate understanding of modern materials and innovative construction methods. Hanson is president of Wiss Jenney Elstner and Associates (WJE), a firm of investigative architects, engineers, scientists, and technicians. Marketing services that combine the skills of these experts, WJE undertakes over 1,500 projects each year.

Hanson cites an example of a modern materials problem. Mortar modified with an innovative additive caused steel structural reinforcements to corrode and building facades to crack and disintegrate. Centran, a parent of Central National Bank of Cleveland, sued Dow Chemical Co., which manufactured the additive, and Dow negotiated a payment of $19 million after a jury awarded Centran $26.1 million. Dozens of similar suits are pending, and more are expected.

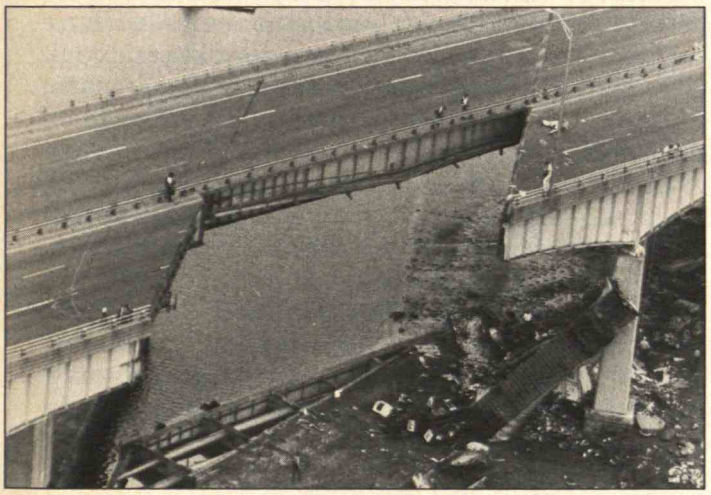
Another case illustrates the dangers of innovative construction methods. A light-gauge metal framing system, which replaced concrete masonry units for residential brick-veneer walls, complied with building codes regulating wall deflections. However, because of the lighter construction, the masonry cracked during heavy winds. Water poured through and the metal framing corroded disastrously. Hundreds of homeowners suffered serious financial loss, and the contractors who built the houses were often sued.

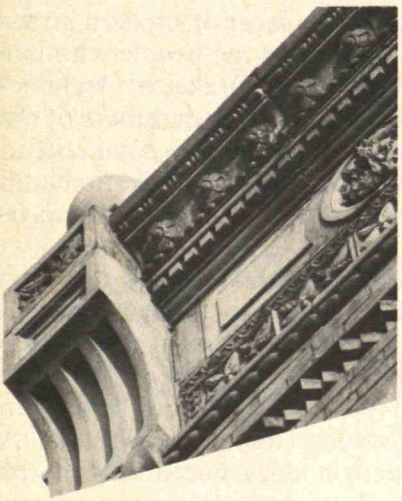
Today's buildings, which use improved, stronger, lighter steels, are more economical to build, enclose more useable space, and yield the slimmer profiles deemed more aesthetically pleasing. But buildings with light steel frames cannot be designed by extrapolating from the rules governing heavier steel structures. In heavier buildings, vibration and acoustics have been dealt with successfully, and the deflection of beams and columns does not affect window frames. But lighter buildings are more prone to vibrations and swaying. Glass may shatter or fall out, walls may crack, and excessive noise may filter from one room to another. Diagnosticians believe wind-induced vibrations caused the glass to fall out of Boston's John Hancock Building.

Hanson and Zetlin both think that professional designers are not properly trained to anticipate the range of contemporary building problems. University study and research traditionally concentrates on



PHOTOS: ERIK ANDERSON, STOCK BOST





Four problems that building diagnosticians handle. Far left: Plywood replaced the windows that fell out of Boston's Hancock Building. Top: Suspended walkways in Kansas City's Hyatt Regency Hotel collapsed. Center: Three people died when this bridge on I-95 fell into Connecticut's Mianus River. Bottom: Terra cotta building facades can explode in the midst of crowded cities.

structural strength and stability, but most of today's failures are not due to these causes. For example, roads and bridges in colder regions deteriorate not because of structural problems, but because of freeze-thaw cycles, de-icing chemicals, and the wear on metal that comes with repeated heavy use.

Zetlin similarly perceives a gap between design-engineering theories and the actual behavior of today's structures. His investigation of the Mianus Bridge collapse underscores his warning that unless we close this gap, we may anticipate more structural failures.

The bridge over the Mianus River was a common type of skew bridge, in which the sides are parallel but the connecting girders are slanted. Though past skew bridges had employed a series of main girders, two heavier main girders were substituted on the Mianus Bridge. They were suspended on six-foot-long steel bars that were connected with heavy steel pins. Failure occurred when straps slipped off the pins. A sophisticated computer analysis, not available when the bridge was designed, showed that the problem was related to time factors not usually considered in determining structural safety: forces acted on the pins cumulatively over a number of years. As a result of Zetlin's investigation, several building codes regulating the design of skew bridges have been modified.

Older Isn't So Good Either

Materials used in the past were not always fully understood, and we now face the consequences of this building ignorance. For example, "terra cotta time bombs" concealed in building facades literally explode in the midst of crowded cities. One reason is that fired masonry continues to grow during its lifetime; only recently have expansion joints been introduced to relieve the pressure this generates. Another cause is that metal ties imbedded in terra cotta are not beyond the reach of moisture as was once thought. When the ties corrode they expand and pop the masonry. If the ties rust through entirely, the masonry loses its support and falls to the street.

In 1979 falling masonry from a Columbia University building killed a Barnard student. As a result, New York City enacted Local Law 10/80 requiring inspections to predict the soundness of facades for all buildings taller than six stories, a height often cited in codes. The law also says that building owners

ANSAS CITY STAR; UPI/BETTMANN; FORREST WILSON

must commission the inspections themselves. Other cities have passed similar laws, usually after a death or serious injury occurred.

Terra cotta is not the only explosive material ticking away. Despite the popular impression that concrete is timeless and indestructible, it is another such little-understood material. This is partly because its history is peppered with experiments and mixtures almost impossible to trace. From the end of the eighteenth century well into the twentieth, buildings were constructed using concrete of undetermined quality and unknown contents. The highly regarded architect Lee Nelson, chief of the Restoration Assistance Division of the U.S. Parks Department, says he would think very carefully before designing a building of reinforced concrete. Many of the historic structures under his care are almost impossible to repair aesthetically. He cites the difficulty of reconstituting badly weathered concrete panels on Frank Lloyd Wright's Unity Temple.

The contents of concrete are often unknown and its quality undetermined. As a result, concrete structures can be extremely difficult to repair. Here workers restore Bethesda Fountain in New York's Central Park.

Nelson also describes the sure annihilation of old forts on the east and west coasts of the United States. These structures, with concrete walls 10 to 12 feet thick, are tearing themselves apart. They crack from the huge stresses that build up within them. The freeze-thaw cycle enlarges these openings, and water pours in, unleashing a ruinous chemical action on the minerals.

The first attempts to set up and maintain standards and quality-control procedures came with the establishment of the American Concrete Institute in 1905 and the Portland Cement Association in 1916. Even so, architects, engineers, and owners of historic concrete buildings have little consistent information to assist them when assessing the conditions of their structures.

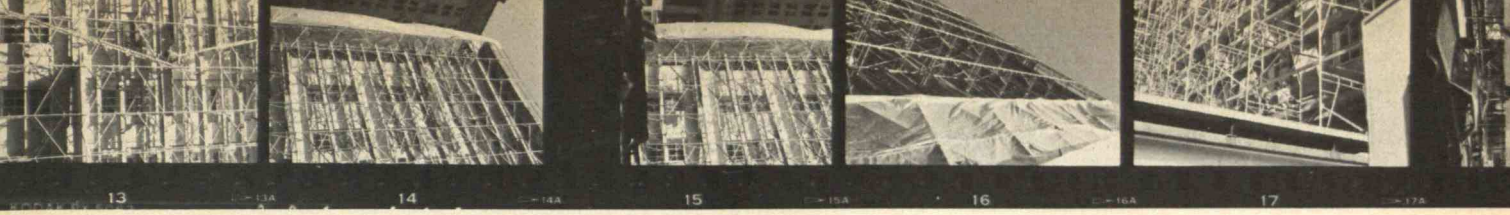
Building walls from the turn of the century were often two-and-a-half feet thick and took 70 or 80 years to deteriorate. The eight-inch walls of modern buildings must be maintained immediately after completion. Another consideration is that today's buildings are larger. And because more exact analyses of structural systems are now possible, safety factors have been reduced and maintenance must be more exact. Buildings are simply less forgiving.

The Human Factor

Perhaps the most significant facet of modern structural failures is their impact on the people who live and work in them. Pleasantine Drake, of Architectural Diagnostics in Canada, claims that most of the time design professionals do not fully comprehend what their decisions mean for the operation and maintenance of buildings—and, hence, for the people inside.

In virtually all buildings, Drake points out, any number of people—from architects to their clients—modify the original layouts. Various types of machines are added, different arrangements of space are specified, and equipment performs differently in real offices than it does in vendors' descriptions. A copy machine salesperson does not dwell on the fumes or noise the product emits. A computer salesperson can't anticipate the glare on a cathode-ray

PHOTO: FORREST WILSON



tube in a particular setting. Even after the building is occupied, the interior design continues to evolve, usually in a haphazard manner.

The response to the energy crisis was to tightly seal and air-condition buildings, since air exchanges cost money. But in the opinion of a number of experts, among them the American Medical Association, such buildings may not be fit for human habitation. Complex mechanical systems create unforeseen health problems. Heating, ventilation, and air-conditioning systems disperse and recirculate the many irritants and pollutants that synthetic materials and modern office equipment generate. Fungi, bacteria, and viruses may incubate and spread.

Further, the industrial detergents and waxes used in maintenance are responsible for irritating and sometimes toxic fumes and dusts, including formaldehyde, hydrocarbons, amines, ozone, and particulates. The popular new sunlight-simulating fluorescent lamps, as well as the standard tubes, give off ultraviolet light; thus they may provide energy for photochemical reactions among pollutants. The result may be indoor smog.

Modern air-conditioning and plumbing have supplied ideal incubation chambers for the lethal, lung-loving germ that causes "Legionnaires' Disease." Air-conditioner recirculating systems and the fine, warm spray from taps and shower heads supply the ideal means of dispersion. This bacterium is now found coast to coast in hundreds of hospitals and large buildings. More than 30 outbreaks of Legionnaires' Disease have been officially recorded.

The outside world is another source of dangerous fumes, as vents draw in air rising from busy streets. Among the most bothersome pollutants admitted in this way emanate from the highly volatile solvents used for roof repairs.

The inside of a building rarely provides for individual needs or desires. A single adjustment of a single theromostat must suffice for young and old, passionate and lethargic, those recently coming inside after physical exertion and those who do sedentary work for hours.

"Mixed-use" office buildings, combining garages, restaurants, offices, health clubs, and more, are increasingly popular. But each of the disparate units emits its own noxious by-products, which often enter the other units: mechanical recirculation systems spread exhausts far beyond the anticipated paths.

Not surprisingly, building occupants are demanding improved environmental quality and more control over the spaces they inhabit. Many express active and vocal resentment. Pleasantine Drake points to the non-smoking lobby as merely one sign of deep dissatisfaction.

Today's "knowledge workers" are not docile. They tape over diffusers, block heating registers, tamper with thermostats, crimp air ducts, cover windows with cardboard or silver mylar, move furniture and equipment, wear earphones or turn on radios, request different work stations, and call meetings away from their offices.

Nor are these workers unsophisticated. They interfere with and shut off building control systems. They attach strips of tissue paper to air diffusers, and when the paper does not flutter, they call building management to complain of headaches and drowsiness caused by the lack of ventilation. They jam letter-openers into locked thermostats, devastating the energy budget. And by union protest and initiating lawsuits, they force employers and therefore designers to respond to their needs.

At the Gregory Bateson State Office Building in California, workers reported unpleasant odors in the areas with the poorest ventilation. The California Occupational Safety and Health Administration performed tests and found dangerous levels of both formaldehyde and carbon dioxide. Fungal spores were identified in air escaping from the rock bed of the building's modern solar-energy storage system. The workers sued contractors, subcontractors, and suppliers. The state had to defend itself against compensation and class-action suits charging health impairment due to poor air quality. The suits are still pending, but the state has already taken steps to improve conditions in the building.

Signs of health problems for workers at Banting Research Centre in Tunney's Pasture, Canada, appeared in late 1981, with reports that women there suffered miscarriages at two-and-a-half times the usual rate. A government health study found that leaks exposed the workers to toxic vapors including benzene, chloroform, dioxins, and PCBs. The problem was exacerbated because the ventilation system had been turned off to save energy, allowing the toxic vapors to linger in already tainted air. The Public Service Alliance in Canada, the union representing maintenance employees in the building, is collecting health files on exposed workers in case future compensation suits are initiated.

The Cure

One objective of building diagnostics is to determine the condition of a building and the people in it. Another is to predict the future condition of both. If there appears to be a risk, diagnosticians propose change.

Building diagnostics works against the destructive specialization that increasingly dominates the building design and construction process. It investigates what happens to building materials over time, documents stresses, predicts impending collapse and failure, and responds to the idiosyncrasies of building occupants. In short, building diagnostics examines the entire built environment to help people make themselves comfortable within it.

Most building failures occur where construction elements meet and where specializations blend together—at the boundaries between building occupant and mechanical system, mechanical system and structure, structure and design. Specialized professionals do not consider connections, but building diagnosticians do. For instance, WJE's range of services includes materials testing, vibration and sound-control studies, facade and roof evaluations, failure investigations, and surveys of the condition of buildings.

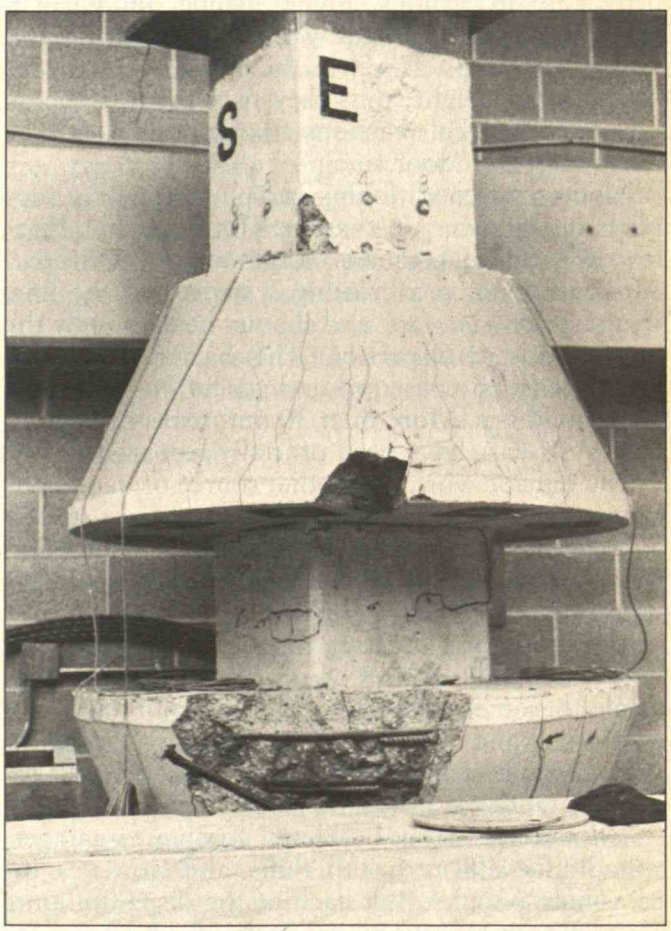
WJE has investigated the Kemper Arena roof collapse; the Hartford Civic Center roof collapse; the Bailey's Crossroads apartment building collapse near Washington, D.C.; and the Horizon Stadium collapse in Rosemont, Ill.

WJE has worked on the restoration of several major historical sites, too. Among those sites are New York's Woolworth Building, built in 1913; the Wrigley Building, built in the 1920s; Louis Sullivan's turn-of-the-century Carson Pirie Scott Building in Chicago; and several Frank Lloyd Wright residences.

WJE's structural analysis of the Woolworth Building, which included research in concrete and terra cotta, has laid the foundation for subsequent diagnostic investigation and repair of major buildings. When the 400,000 pieces of terra cotta on the building's facade began to deteriorate faster than maintenance groups could fix them, WJE and the Ehrenkrantz Group of New York City undertook building diagnosis and restoration. Their on-site laboratory tests revealed three problems: cracking caused by incompatibility between the surface and body clay; rusting of steel ties due to water seepage; and high internal stresses resulting from a lack of expansion joints. WJE recommended techniques to relieve the high stresses, including re-anchoring or replacing sections of unsound terra cotta.

WJE also provides blast-monitoring and consulting services to quarries, mines, cities, and the construction industry. They use seismographs and other sensors to monitor and control the size of blasts near underground utilities, radio and TV towers, and buildings. They frequently monitor vibrations during pile driving, assessing the potential damage to structures in the vicinity.

When cracks in welds were discovered on Oregon's 2,150-foot Fremont Bridge soon after construction, WJE evaluated the integrity of the bridge and developed a repair program. To pinpoint the cracks, WJE engineers examined critical parts visu-

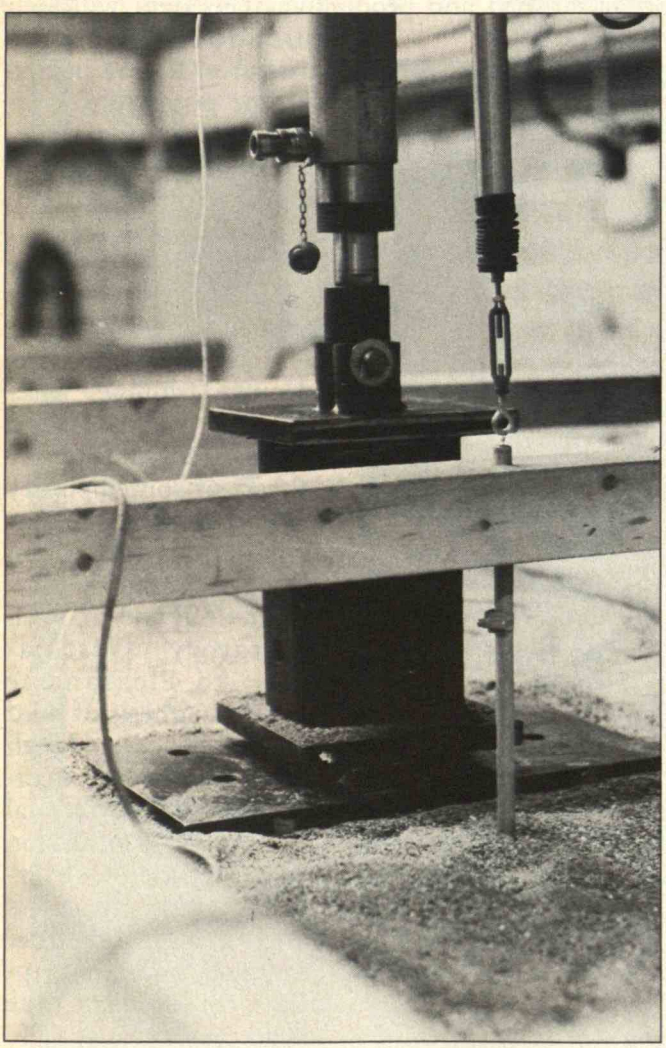


Above: Building diagnosticians at Wiss Jenney Elstner and Associates developed equipment to help repair reinforced concrete structures. Right: A test simulates the load on pipe buried in sand.

ally and with the aid of dye. The engineers removed sections of suspected welds for metallurgical examination. To monitor the effects of traffic and temperature changes, they placed strain gauges at selected locations. They conducted full-scale load tests with heavily-weighted construction equipment. WJE's repair and ongoing inspection program, which uses test data and a computer analysis, now ensures safe travel on the Fremont Bridge.

The Human Sensor

Advances in the instrument technology central to WJE's work gave building diagnostics its start. But the human senses are the most valuable diagnostic devices. Nowhere is this more evident than in the investigation of building vibrations. Long before vibrations pose a threat to a structure, occupants consider them intolerable. One nineteenth-century building code, which recognized three levels of seismic intensity, stated that the first was reached when "startled persons leave their dwellings." The second was reached when "cracking of plaster and minor cracks appeared in walls" and the third when walls "cracked or collapsed." Even today, tall buildings are much stiffer than structural integrity requires, and the reason is simply to avoid human distress.



Building diagnostics also bridges hard, physical sciences and soft, social sciences in its consideration of odor. Instruments can measure known gaseous and particulate compounds of air pollution, but none can accurately analyze smells. The human nose is the only reliable sensory device.

Moreover, though instruments can measure the effects of pollutants, air circulation, temperature, daylight, and artificial light, the synergy of those effects in a single system is not readily quantifiable. Yet from the occupants' point of view this system constitutes the building itself.

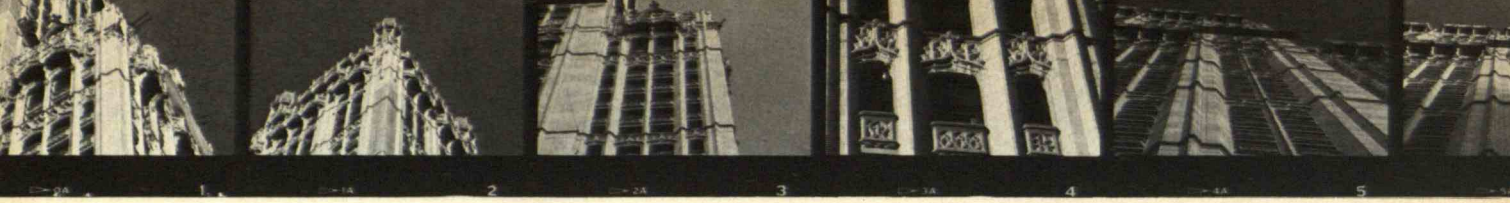
The fact is that the entire building and the people in it form an integrated whole. Malfunctions or disasters are never isolated incidents. High absenteeism and low supervisory ratings may be caused by poor management, but they can also coincide with grating noises, stagnant air, uncomfortable temperature, bad lighting, or intolerable glare.

A failure of building materials can trigger a health problem. In one instance, a faulty joint over a parking area in a Los Angeles building admitted exhaust fumes to an office reception area above. The receptionist became seriously ill. Her respiratory seizure was a symptom of building sealant malfunction.

Also, single malfunctions quickly and invariably affect a range of building interactions and elicit several different human responses. For example, an office manager may note a crack in a wall. A structural engineer might be contacted, but a careful examination of the wall may uncover a plumbing problem, such as a faulty pipe connection. A mechanical or electrical engineer may be called when air seeping through the crack drives up heating costs, and a psychologist may have to handle employee complaints.

Even the measurement tools and methods initially developed to investigate one building condition automatically indicate several. Scans used to detect heat

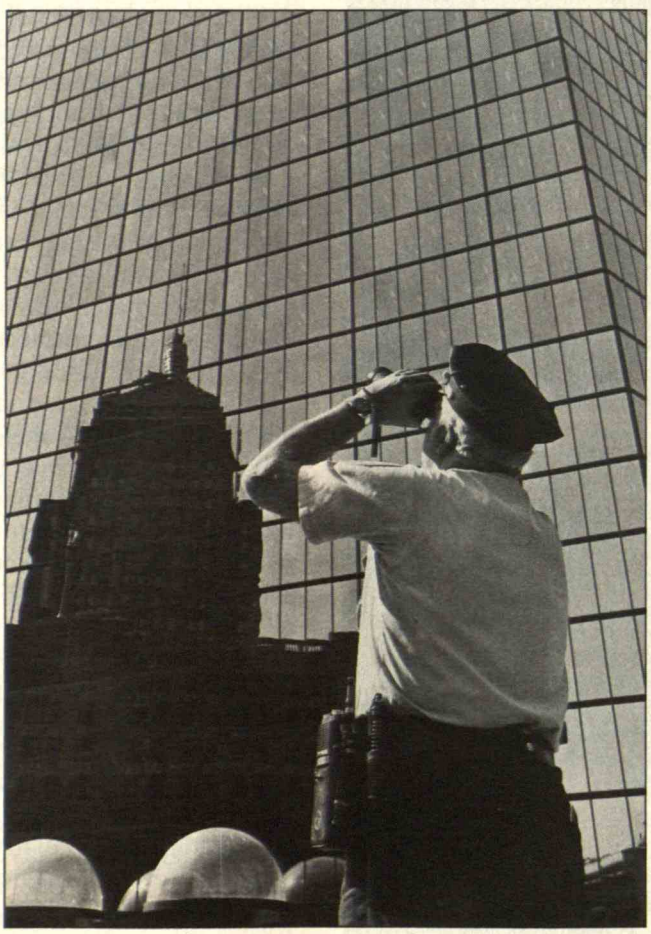
PHOTOS: FORREST WILSON



loss cannot help but indicate roof leaks, missing insulation, structural incongruities, overheated electric wires, and, with judicious interpretation, occupant comfort.

So, recognizing that all design concerns are related, building diagnosis merges the specialties. Structural engineers familiarize themselves with plumbing, ventilation, metallurgy, and the behavioral sciences. Psychologists become adept evaluators of lighting and mechanical systems. For example, research psychologist Arthur Rubin, at the Center for Building Technology of the National Bureau of Standards, is a nationally recognized authority on lighting quality, building acoustics, the design of automated offices, and office technology. Fred S. Dubin, a well-known and highly respected mechanical engineer, retained a medical doctor on his firm's staff to diagnose human response to the environment mechanical systems create. Dubin later became involved in energy design and management, and then worked with the National Institutes of Health on air-quality problems. Recently he earned a degree in architecture.

Overall, performance is the primary criterion for diagnosticians. If a building is to provide comfortable conditions for the people who work sitting down during most of the day, this objective must be stated as the first design priority. According to John Eberhard, director of the Building Research Board of the National Research Council, performance descriptions for building materials and spaces should be written only after comprehensive human-based standards have been formulated.



This guard watches Boston's John Hancock Building, looking for signs of window stress.

Buildings That Succeed

Building diagnostics, still in its infancy, is the beginning of a comprehensive building science. About 90 percent of its information base is empirical wisdom—what has worked and what has not—and the remaining 10 percent is scientifically generated knowledge. Because of new systematic research and new attitudes, that base is growing. Only a little over a decade ago the first technical successes occurred when infrared thermography was used to test structures for energy efficiency. Since then building diagnostics has infiltrated every facet of design and construction.

Moreover, diagnosis does not always center on failures. It is increasingly employed to help buildings work right. Diagnosticians have developed and collected valuable data on buildings in which people appear satisfied and productive. This data will yield guidelines for future structures. It may indeed become possible to predict the behavior of structures and the people in them as an integrated, single whole.

The problems that created the need for building diagnostics remain: fragmented professions, inadequate training, deteriorating materials and systems, and the unique dangers of contemporary work environments. But diagnostic work—from the sophisticated hard scientific analysis of WJE laboratory investigations; to Pleasantine Drake's synthesis of hard and soft sciences; to Hugh Miller's intuitive decisions based on the sensual gathering of information and a lifetime of observation and experience—is making a difference. Prognosis and prescription may someday take the place of autopsy. □

PHOTO: BARBARA ALPER, STOCK BOSTON

Assessing Risks from Health Hazards: An Imperfect Science

BY DALE HATTIS AND DAVID KENNEDY

When William Ruckelshaus came back to run the embattled Environmental Protection Agency (EPA) in 1983, one of his primary goals was to separate the "science" of assessing health hazard risks from the "policy" of managing those risks. During the previous administration of Anne Burford Gorsuch, risk assessment had become so entangled with politics that many public observers felt that the EPA was acting as an advocate for the very industries it was supposed to regulate. For example, the EPA had concluded that there was no significant health risk to workers from exposure to formaldehyde, a chemical used to make particle board, plywood, and some permanent-press fabrics. The actual evidence on the health risks from formaldehyde was less reassuring than the EPA's position indicated.

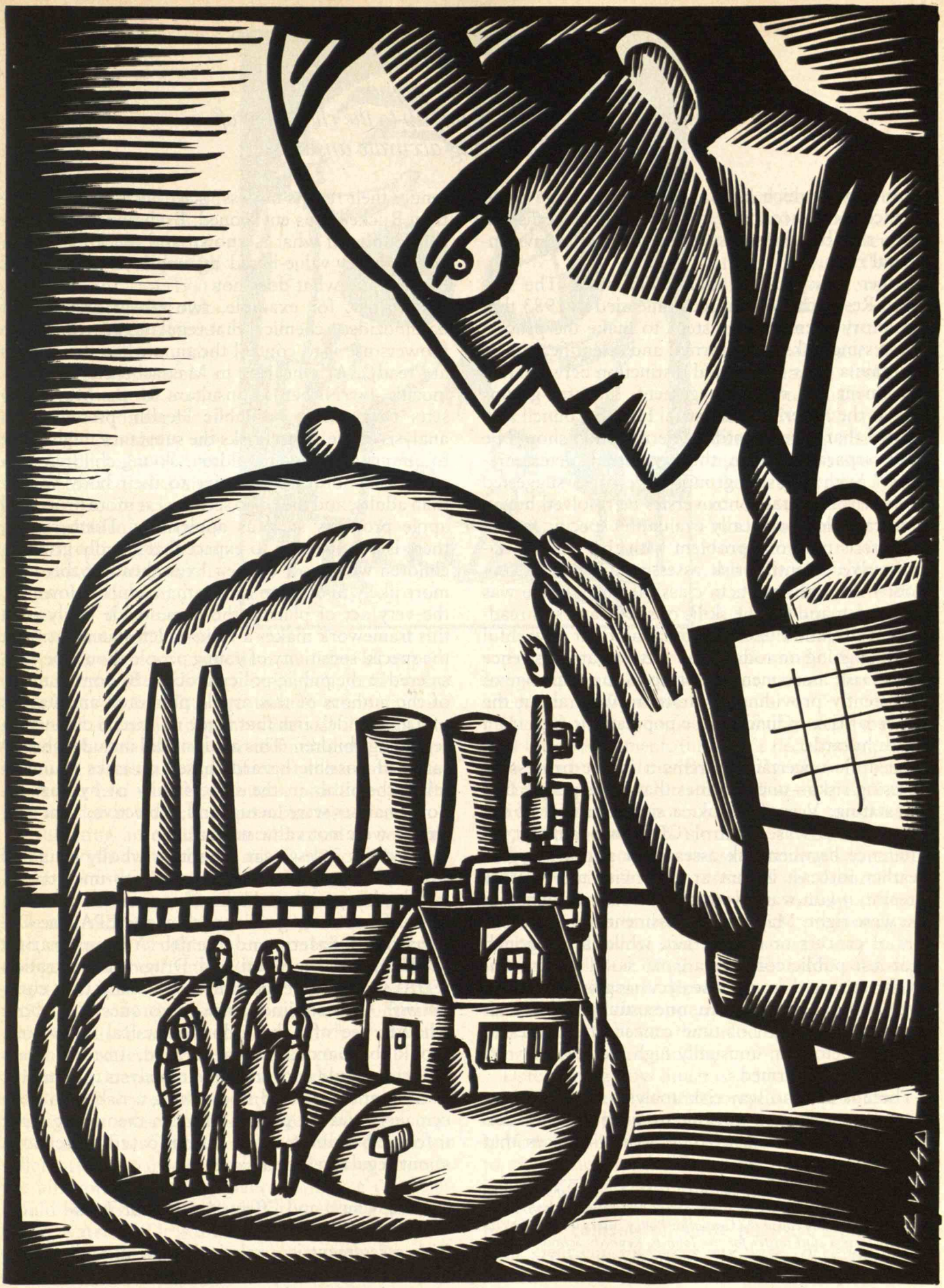
In an effort to make risk assessment more impartial, Ruckelshaus argued that scientists should first make an "objective" study of the extent of risk from exposure to a particular hazardous chemical or situation. How many people, for example, will die from cancer after 20 years of exposure to airborne arsenic emitted from a copper smelter in Tacoma, Wash.? Only after that assessment is made should governmental agencies move into the political realm and decide what to do about that risk.

Moreover, Ruckelshaus thought that his agency would better serve the public by being more explicit about the extent of risk from various environmental hazards. Potent carcinogens such as dioxin are very frightening, but just how dangerous is a very low concentration of the chemical? Should the EPA take great pains to reduce dioxin in waste sites to very low levels, or might the money spent on such cleanups save more lives if channeled toward controlling other kinds of pollution? Ruckelshaus believed that risk assessments comparing the threat from different hazards would help him, and the public, resolve such issues.

Ruckelshaus' intent was to create a special authority and credibility for risk assessment. He wanted to build a strong scientific foun-

Quantifying people's risks is a process rife with uncertainty. Analysts should make public those uncertainties so we can make more informed decisions about controlling hazards.

ILLUSTRATIONS: ANTHONY RUSSO



The science behind risk assessment is simply not up to the challenge of consistently providing accurate answers.

dation upon which EPA and society at large could balance social, economic, and political concerns and reach sensible decisions about managing environmental risks.

Other policymakers shared his views. The National Research Council recommended in 1983 that regulatory agencies take steps to make the process of assessing risks more formal and scientific, and to maintain a clear conceptual distinction between risk assessment and risk management. Industry groups such as the American Industrial Health Council also insisted that "the scientific determination should be made separately from the regulatory determinations." Such industry groups have often suggested that environmental controversies be resolved by experts capable of critically evaluating specific facts.

There is only one problem with this call for authoritative, scientific risk assessment: such a commodity does not exist. In classical times, there was a great demand for the skills of soothsayers in reading entrails, and there is a similar amount of wishful thinking going on today. The fact is that the science behind risk assessment is not up to the challenge of consistently providing accurate answers about the degree of risk individuals or populations face from health hazards.

Scientific uncertainties remain in the process of assessing risks—uncertainties that some people find devastating. Vernon Houk, a senior official of the Centers for Disease Control (CDC), has said that the difference between risk assessment and a five-year weather forecast is that at least with the weather forecast, if you wait five years you find out whether you were right. Many risk assessments project numbers of cancers or deaths that, while large enough to arouse public concern, are too small to be definitively separated from those occurring normally in a given society. Furthermore, one usually has to wait decades—the length of time cancer often takes to emerge—before an unusually high incidence of disease can be confirmed.

There is also no way risk analysts at the EPA or other agencies can escape making value-laden choices in the course of their work—choices that render their results far less "scientific" and objective than Ruckelshaus envisioned. Even apparently neutral reports of what is known and not known generally reflect value-based assumptions about what matters and what does not.

Consider, for example, two recent analyses of daminozide, a chemical that regulates growth (apple growers use it to control the time when their crops are ready). At a hearing in Massachusetts on daminozide, Ian Nisbet, a consultant for the Massachusetts Department of Public Health, presented an analysis of the special risks the substance might pose to infants and young children. Young children generally eat more food relative to their body weight than adults, and they also seem to eat more processed apple products such as applesauce. Furthermore, there is good reason to expect that rapidly growing children with most of their lives ahead of them are more likely to develop cancer than adults. However, the very act of placing the daminozide analysis in this framework makes a value-laden statement: that the special sensitivity of young people should be considered in the public-policy process. By contrast, one of the authors of this article presented an analysis of daminozide's risk that made no special distinction regarding children. This analysis did include a broad range of possible hazards based on risks found in other chemicals in the same family of hydrazines. Both analyses were factual and "objective," but they clearly were not value neutral.

Since risk assessment cannot be wholly insulated from value judgments and is rife with uncertainty, it lacks the special credibility that some would claim for it. Therefore, agencies such as the EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) should not expect their risk analysts to come up with "bottom-line" answers to questions about whether use of a hazardous chemical or process should be banned or encouraged. Instead, these agencies should encourage their analysts to share the uncertainties involved in assessing a risk with policymakers and the public, who can then make more informed—albeit more complicated—decisions about regulating the risk.

Linking Cause and Effect: A Difficult Task

Risk assessment is a relatively new discipline, if it can be called a discipline at all, and there is no con-

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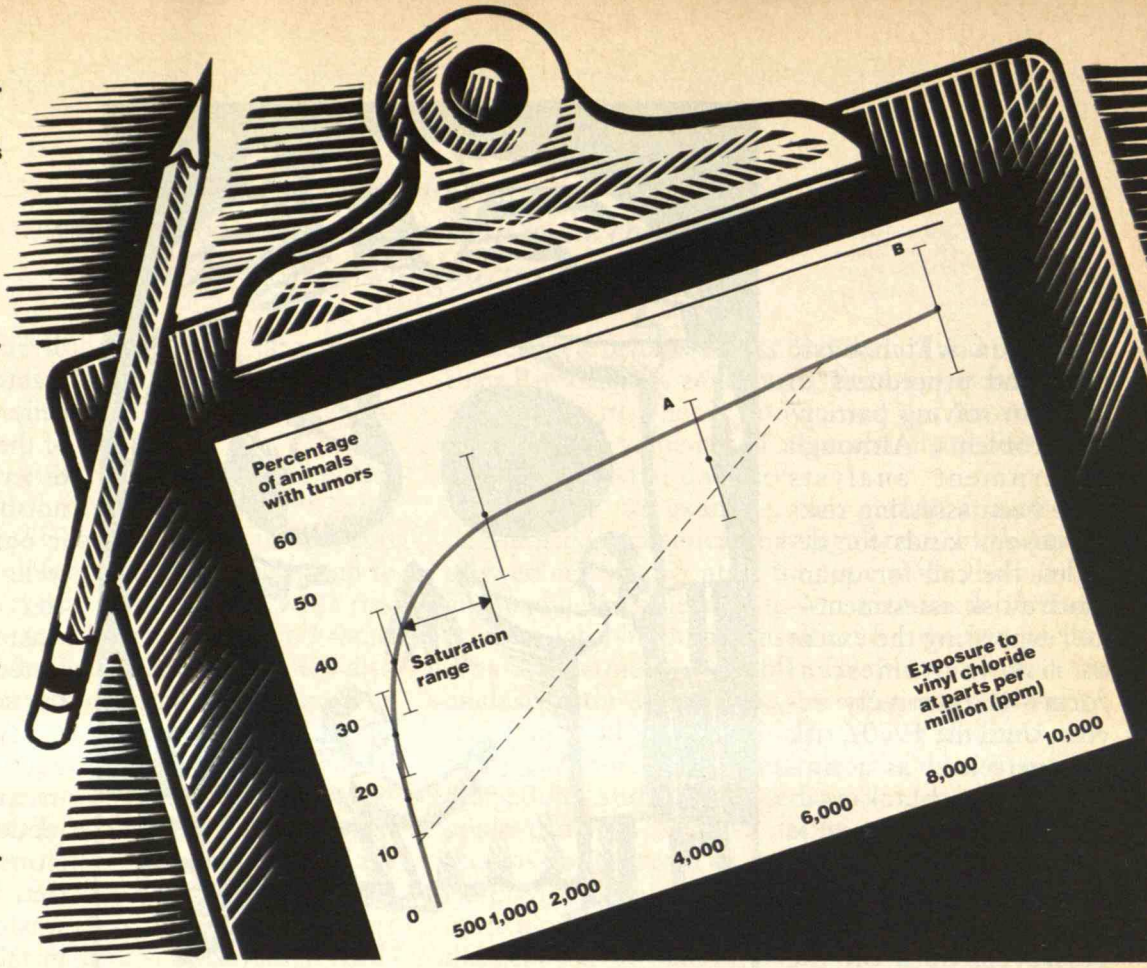
sensus on which basic rules and procedures to apply in solving particular problems. Although government analysts have been assessing risks of various kinds for decades, the call for quantitative risk assessment—i.e., expressing the extent of risk in numerical form—is relatively recent. Until the 1970s, risk was perceived as a simpler, more black-and-white problem: is or is not DDT carcinogenic and mutagenic? The answer is an unequivocal yes. However, data on the risks of many other toxic substances are more ambivalent, and the risk to people remains unclear. In such cases, policymakers are more likely to take into account the economic consequences of restricting the chemical in question. More sophisticated detection technologies also allow scientists to measure the effect of these substances in smaller and smaller amounts, producing results that are not as clearcut as previous tests were.

Evaluating an environmental hazard to see how many people might be at risk is difficult because analysts must follow that hazard through whatever twists and turns it takes in the real world. Analysts have to determine how potential threats are released into, and move through, the environment. They have to figure out how much of the substance people might eat, breathe, or otherwise take up, and then estimate how much of it they would absorb. Finally, analysts must determine just how much of a hazard the absorbed level of the substance poses.

Figuring out how much of a toxic chemical reaches people—the degree of exposure—can be quite challenging. For example, analysts generally use computer models to assess how a toxic plume of different-sized particles of arsenic disperses through the air from a smelting plant, or how a chemical would be carried through the ground to wells supplying water. Yet it is difficult to incorporate all the important information into these models. In most cases groundwater flows more readily in horizontal directions (out from a waste site) than vertically. But measurements of the way water flows in different directions may not be available, making it hard to predict when wells at different depths and distances from the waste site might be affected. Even when data of this sort are available, the models themselves often oversimplify the system in question. One EPA model of smelter emissions into air assumed that the smelting plant was on a flat plain when in fact it was on a steep hill. As a result, EPA scientists misstated the wind patterns and initially overestimated the concentrations of arsenic that would affect the nearby town.

Even if analysts know how much of a substance is in the environment, they can't necessarily predict how much people will actually absorb. People breathe at different rates depending on their level of activity: workers laboring heavily at a construction site, garment workers sitting at sewing machines, and people sleeping in the surrounding community will all receive different doses of an airborne contaminant. Individuals also have widely different breathing rates and dietary habits, profoundly affecting the doses of specific substances they receive from air and food. Finally, people absorb substances in varying amounts depending on the thickness of their skins and the properties of their nasal mucous, and even on whether they tend to breathe through their noses or their mouths.

Determining how much of a hazard the absorbed substance poses is another complicated problem. For example, evidence of cancer or other toxic effects in humans attributable to a specific cause would seem to constitute the ideal basis for regulation. A high incidence of lead poisoning in people living near lead smelters would seem to indicate the need for better pollution controls on those plants. Unfortunately, such clear-cut instances are rare, because epidemiological studies are notoriously insensitive in de-



Extrapolating the results of animal studies to humans can be complicated. Animals are exposed to large amounts of chemicals so that toxic effects will appear at significant levels. However, at these doses, the animal enzymes that convert the chemicals to cancer-causing substances become saturated and cannot make any more toxic by-products. This effect occurred when rats were exposed to increasing doses of vinyl chloride. The curve showing how many animals developed tumors leveled off shortly after the saturation point.

Risk assessors usually apply only the data from the two highest dose points (A and B) to weigh human risk. If they had done so in this case, the curve would have been a straighter, more gradual line, greatly underestimating the human risk at low doses.

tecting health effects from relatively low levels of exposure. As David Ozonoff, chief of the Environmental Health Section at the Boston University School of Public Health, has said, "A good working definition of a catastrophe is an effect so large that even an epidemiological study can detect it."

The problem is that the rates of specific illnesses from a given hazard often must be several times above average before one can conclude that they aren't simply random fluctuations. In one celebrated case now being tried, a group of parents from Woburn, Mass., is suing two chemical companies for dumping toxic wastes in the neighborhood. The parents claim that these wastes leaked into local drinking water and caused an unusually high incidence of leukemia among their children. This high incidence, which has already resulted in the deaths of five children, could indeed be due to the companies' toxic-waste dumping, or it could be a random fluctation. It could also be the result of a completely different and unknown phenomenon.

Another complication is the fact that unless scientists perform special monitoring measures at the time of exposure, there is rarely good information about how heavily certain populations have been exposed to a chemical. Nor is information about "confounding" factors such as smoking, alcohol use, and the toxic's interactions with other environmental hazards readily available. These difficulties do not always render epidemiological information useless: solid positive results can provide a good indication of a specific level of risk from a given substance. For example, studies among workers exposed to arsenic, and among residents exposed to arsenic compounds in well water, have unequivocally revealed the carcinogenic properties of inorganic arsenic. However, a negative result is usually not proof that there is no risk, but rather an indication that the risk, if any, is less than the study is capable of detecting.

The Trouble with Animal Studies

In the great majority of cases where the epidemiological evidence is incomplete or ambiguous, using animal studies to make projections may make more sense. However, such studies suffer from their own serious uncertainties. Experimental animals are generally exposed to high concentrations of chemicals to ensure that if there are any toxic effects, they will appear at statistically significant levels. A mathematical model called a "dose-response curve" has to be fitted to the resulting data to assess the probability that people will get cancer at the much lower levels they might realistically encounter. However, such high doses can complicate the interpretation of results in a number of different ways.

For example, molecular biologists have discovered the existence of certain enzymes in cells that convert chemicals to more toxic metabolites, beginning the march toward cancer. At very high doses of the toxic

ILLUSTRATION: ANTHONY RUSSO; DIAGRAM: OMNIGRAPHICS

Epidemiological studies are notoriously insensitive in detecting health effects from relatively low levels of exposure.

substance, these enzymes are fully occupied and cannot generate toxic by-products at a greater rate. Thus, increased doses do not necessarily lead to more cancers. In extrapolating downward to realistic levels of human exposure, risk assessors often don't take this saturation effect into account and, in effect, underestimate the risk to humans.

Ideally, the dose-response relationship would be derived from a detailed theory about how the chemical actually works to produce cancers in animals and in humans. Such a theory would be based on knowledge about how the chemical is absorbed, metabolized, and excreted from animal and human systems. Risk assessors do not generally attempt to draw together much of the latest knowledge available, and as a result their models do not capture the details of cause-and-effect relationships. Instead, these analysts generally fit one of a number of statistical formulas to the data on tumor formation.

Unfortunately, the different mathematical models produce widely varying results. "Multistage" models, favored by molecular biologists, are based on the belief that cancer occurs as the end result of a series of genetic changes in specific cells. If a toxic chemical interferes with the copying of the genetic information in a cell's DNA, the errors, or mutations, will usually be passed on to the descendent "daughter" cells. Even if the error is confined to a single nucleotide base on the DNA code, the results can be severe if important genetic information is altered.

For example, in some cases a cancer-causing gene known as an oncogene becomes active because of a single mutation: one specific nucleotide is replaced with another. That one change instructs the gene to produce a specific amino acid instead of another. Chains of amino acids link together to form proteins, the basic molecules that help cells function. In this case, the single change in this amino acid produces a protein that begins the process of producing cancer, although researchers do not yet know how. The crucial implication of this model is that even the tiniest amount of a toxic substance that can affect DNA has some chance of inducing cancer. In principle, there is no exposure threshold below which the toxic substance does not pose a risk.

In contrast, "probit" models imply that individual organisms do in fact have a specific tolerance level, or threshold, below which exposure to a toxic chemical is safe. This type of model is traditionally favored by pharmacologists and toxicologists, who view biological processes as complex webs of processes, exquisitely balanced so that modest perturbations in the system will prompt corrective actions to restore normal functioning. As long as the biological insult the system suffers is not too great—i.e., is below a certain threshold—the system ought to be able to repair any damage that may be temporarily produced. The implication is that there is no benefit from regulating toxic substances when exposure falls below such a threshold.

Many scientists believe that this type of model is perfectly appropriate when applied to traditional types of acute toxic insult, such as the lung damage from methyl isocynate that occurred on such a devastating scale in Bhopal. However, some scientists find this model more questionable for carcinogens that seem to act directly or indirectly on DNA. Furthermore, given the difficulties of extrapolating human exposure from high-dose animal experiments, there is rarely, if ever, any way to specify actual thresholds for people.

Despite these reservations, risk analysts continue to use very different models depending upon their professional ideology. And the results continue to differ dramatically. In a recent experiment, Alice Whitemore, an epidemiologist at Stanford University School of Medicine, fit different models to experimental data for male rats exposed to the carcinogenic pesticide ethylene dibromide (EDB). Widely used to fumigate grain, EDB has recently been found in bread, cereal, cake mixes, and the like. Whitemore found that depending on the model chosen, the likelihood that an individual will get cancer from low-level exposure to EDB can differ by a factor of one million.

Given these enormous discrepancies and what is at stake for industry, workers, and the general public, there is considerable controversy as to which models are most appropriate for assessing risks. Analysts at EPA and OSHA tend to use the more conservative multistage model, favored by molecular biologists, or a similar model. For instance, OSHA used this model in a recent assessment of the risk of workers exposed to EDB. This assessment, which was based on extrapolation from an experiment with rodents, showed that the risk is very high indeed: after 45 years of intermittent exposure to 20 parts per million of EDB in the air—the maximum amount then permitted under OSHA standards—the chance that a worker would develop one common form of

Risk analysts should try to eliminate, or at least disclose, biases in their thinking.

cancer was pegged at between 38 and 59 percent. However, very few workers were actually exposed at this level or for this duration; the calculation was done to show that there would be a "significant risk" to workers if they were exposed over a working lifetime to the permitted levels. OSHA, however, has not yet reduced its maximum level of EDB exposure in the workplace.

When results from the multistage model lead an agency to ban or severely restrict the use of a chemical, fireworks often result. For instance, the EPA's recent ban on the use of EDB as a pesticide prompted a vociferous protest from companies that manufacture the chemical. However, the ban has stood.

Other serious difficulties plague the process of interpreting animal studies and extrapolating them to humans. Because animals and humans metabolize substances differently, the level of the test chemical that reaches various parts of the animal and the human body can vary widely. Hence, animals and humans may suffer from different health effects. For example, bis-chlormethyl ether, used as a laboratory chemical, tends to produce nasal tumors in rats but lung tumors in people. The contrast may stem from differences in how deeply the chemical penetrates into the respiratory system before being absorbed.

Moreover, the metabolite or by-product of the test chemical, rather than the chemical itself, is often the toxic substance, and animal systems can differ from human ones in the type and concentration of metabolites they produce. For example, dogs and people primarily succumb to bladder cancer from some aromatic amines such as benzidine (used in the manufacture of dyes), while rodents get cancer of the liver. This is apparently because the different mammalian systems form metabolites that react at different sites in the body. As the National Research Council, which often advises the federal government on scientific issues, points out in a recent congressionally commissioned report, correcting for these differences is not easy because researchers often lack enough information about human and animal systems.

Disclosing Bias in Risk Assessment

It would be easy, but mistaken, to look at this litany of problems as a wholesale indictment of the entire concept of risk assessment. William Ruckelshaus himself came close to drawing such a conclusion in 1985 after leaving the EPA. He wrote that risk analysis "is a kind of pretense; to avoid paralysis of protective action that would result from waiting for 'definitive' data, we assume that we have greater knowledge than scientists actually possess and make decisions based on those assumptions."

Although now more aware of its limitations, Ruckelshaus still believes in risk assessment, and Lee Thomas, the current EPA administrator, is pursuing his predecessor's vision of higher-quality risk assessments. And properly so, since some form of risk assessment is essential in dealing with environmental hazards. There is real value in encouraging a conceptual and professional separation between risk analysts and risk managers. Such a separation will never produce the kind of ironclad and unimpeachable scientific analyses some would like. However, it will reinforce the preeminent duty of analysts to eliminate inappropriate biases from their thinking and work.

The sort of thing to avoid is the EPA's handling of formaldehyde under Gorsuch. In 1981 the agency in effect took an advocacy position to support a decision that regulation was not necessary. Its assessment suggested that there was no significant risk because its analysts lacked epidemiological evidence that the substance is carcinogenic. The analysts relied instead on arguments about thresholds to conclude that low-level exposure is safe. Most risk assessors know how slippery epidemiological data are, and they are familiar with the vigorous debate regarding the viability of thresholds for carcinogenicity. The EPA ignored such ambiguities. Norton Nelson, a prominent environmental scientist, said that the EPA took "an extreme position" in deciding that the data on health risks of formaldehyde were not very significant.

Risk analysts should be encouraged to cultivate an approach—an ideology, if you will—that provides the public with exactly the opposite of extreme, advocacy positions. Since risk assessors often cannot answer the question "exactly how much risk does some hazard pose?" they must tackle the question they can answer: how much do we know about a particular hazard, and what are the important uncertainties in that picture?

The objective of this approach would be to help policymakers and the public make informed choices based upon the available information. Risk assessors of this stamp will have to be particularly open and

sensitive in choosing which methods of analysis are appropriate in each situation. They will also need to draw on insights from various disciplines. Take, for example, the original studies assessing the risk of workers exposed to airborne lead. Since workers exposed to less lead didn't have correspondingly reduced blood lead levels, some scientists originally suggested that much of the lead found in workers' blood must have been introduced by some mechanism other than breathing. However, pharmacologists know that lead is stored in bone when blood is saturated, and can be released into the blood if blood lead levels fall. The original scientists didn't take that important fact into account and came up with the wrong assumption that workers were somehow eating the lead.

Risk assessors should be intimately familiar with such effects and be able to apply the insights and techniques of different specialties where appropriate. Unfortunately, risk asessment practices today tend to prevent such interdisciplinary familiarity. Many government risk assessors are not trained in toxicology, biochemistry, or other disciplines. Thus, they often do not have the background to understand and include in their assessments the detailed processes that produce disease. Instead, risk analysts usually review the research of other specialists and use statistical methods to draw quantitative conclusions.

Specialists from different disciplines such as pathology, toxicology, and chemistry often form teams to perform risk assessments, which is a step in the right direction. But there's still a tendency to maintain strong disciplinary boundaries on such teams—to separate, for example, the analysis of the dose people are exposed to from an analysis of how that dose correlates with actual health effects.

Take exposure to formaldehyde. The substance can affect respiratory tissue in a number of ways. The formaldehyde can itself react with DNA and begin the process that ultimately can lead to cancer. It can also inhibit the enzymes responsible for repairing DNA. Finally, at high doses, it can kill cells and thereby stimulate cell replication to replace those that are lost. Enhanced cell replication reduces the time available for repair of DNA lesions, increasing the chance that permanent genetic changes will occur in the exposed cells. Given these multiple effects, there is some reason to suspect that short-term exposure to high doses of formaldehyde might cause more damage than longer term exposure to the same total amount. Hence, OSHA and EPA should express their results in terms of the amount of time people spend at specific exposure levels. Unfortunately, these agencies now express exposure levels as an average over time.

Some of this tunnel vision can be blamed on the narrow and often uncoordinated focus of the risk assessors. But the agencies themselves must take the blame for not acting quickly enough on important new information; pressure from agencies such as the White House Office of Management and Budget, and the potential for lawsuits from industry and citizen groups are two reasons for such lethargy. Some officials are reluctant to try innovative approaches to risk assessment because they may be more likely to be shot down in the tortuous process leading to a regulatory decision.

Risk assessors also must do a better job of deciding what the scope of their analyses ought to be. For example, they have to decide whether to include the possibility that a toxic chemical may interact dangerously with other chemicals in the environment, even though there are no hard data available on that interaction and its result. Risk assessors also have to decide who to consider when analyzing a chemical's toxicity. Take the case of ozone, a pollutant formed when hydrocarbon fumes evaporate from automo-

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A new satellite provided the first telephone link between earthquake-stricken Mexico City and the Mexican consulate in Los Angeles, helping hundreds of anxious callers learn whether their relatives had survived the disaster. The consulate, located in the city with the largest population of Mexican citizens outside of Mexico City, was flooded with calls after the 7.8-magnitude quake on Sept. 19. For help, it turned to Hughes Aircraft Company, which had built the country's three-month-old Morelos communications satellite. Hughes engineers located a shipment of communications equipment en route to New York City and diverted it to the satellite ground station outside the Mexican capital. Meanwhile, an antenna at the Hughes ground station near Los Angeles was pointed at Morelos. To complete the phone line, the engineers established a microwave link between the ground station and company offices, then hooked into the local phone system to the consulate. The line was kept open 24 hours a day.

A private, domestic satellite system will carry telecommunications throughout Japan beginning in early 1988. The system will be owned and operated by Japan Communications Satellite Company, Inc., a joint venture composed of Hughes Communications, Inc. (a Hughes subsidiary) and Japanese partners C. Itoh & Company, Ltd. and Mitsui & Company, Ltd. The joint venture firm has ordered two large, high-power satellites based on the new Hughes HS 393 spacecraft. These satellites will allow users to receive voice, television, and data transmissions through small, low-cost ground terminals. Each satellite will have 32 transponders, providing capability to transmit 32 channels of TV programming or a mix of TV and other communications. The satellites are scheduled for launch in December 1987 and April 1988. Services are expected to begin in February 1988.

Enhancements to NATO's air command and control system will include provisions for interoperability among all member nations, as well as a variety of systems that will prevent gaps in the network. These enhancements to NATO's C^3I (Command, Control, Communications, and Intelligence) system will also include the expanded use and reliance on advanced high-speed digital computers to sort vital information from sensors and immediately relay it to commanders in the most useful form. Hughes is part of an international team that is studying NATO's needs and defining just how the command and control network should be upgraded.

A new processing technique eliminates impurities in an optical fiber that has promising uses in the mid-infrared region of 1 to 5 micrometers. Zirconium fluoride glass fibers, which are typically prepared in an atmosphere of inert gases, contain defects that scatter light transmissions and preclude their use in long fiber links. Scientists at Hughes Research Laboratories, however, have prepared molten glass at 850°C using a novel reactive atmosphere process. This special process completely eliminates the chemical interaction with impurities, which yield light-scattering defects.

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An informed public will have to accept responsibility for making painful choices among competing goods.

bile exhausts, gasoline, and paint solvents and react with sunlight. Should analysts focus on the risk to the majority of relatively healthy people, or to the relatively few elderly and asthmatic people who might be particularly susceptible to ozone smog?

Analysts must recognize that such choices are laden with value judgments and make an effort to avoid or least state those judgments. Yet all too often, as John Holdren of the University of California at Berkeley has written, risk assessors tend to omit issues that they have decided are too uninteresting, difficult to quantify, speculative, or likely to be "misinterpreted." To prevent this kind of preselection, we should ensure that analysts publicly disclose the choices they make.

A Cure for the "Bottom-Line" Illness

Finally, risk assessors must do a better job of identifying and assessing uncertainties and communicating them to policymakers and the public. Given the many difficulties with the science that risk assessment draws on, analysts should take care that it is never said of them, as it has been of the State Department: "They're never right, but they're always sure." The goal here should be, in the words of Nicholas Ashford, associate professor of technology and policy at M.I.T., to "bound the set of not clearly incorrect answers," rather than to focus solely on the most likely answer statistically.

Risk analysts should never present a "best estimate" of risk without some accompanying statement of statistical uncertainties and other ambiguities. Policymakers often suffer from "bottom-line illness"; all they want is the number at the end of the study. Risk assessors should carefully avoid that disease. Instead of one bottom-line estimate, they should present a range of likely estimates, including their different consequences.

We could formulate many other such prescriptions for analysts, but the basic principle is that they should communicate their findings so that policymakers and the public can fully understand the issues and uncertainties. Interested observers should be able to comprehend the important assumptions, data gaps, and choices almost as if they themselves had gone through the process. This is all the more important at a time when the U.S. has limited resources for making its environment "safe" from hazards. As Ruckelshaus said recently, we have to "abandon the impossible goal of perfect security and accept the responsibility for making difficult and painful choices among competing goods."

In a more paternalistic society, an elite group of leaders might weigh competing costs and benefits and set safety limits for the rest of us according to the elite's view of what is best. But we live in a democracy and have a right to participate in the dialogue concerning which risks should be controlled and to what degree. Moreover, we have to consider the fact that the cleanup itself is not generally risk free: workers can become injured and nearby residents can be exposed to air pollution from bulldozers cleaning up a site.

Risk assessment can help inform this important social and political dialogue. It can also help raise the quality of that dialogue, by revealing where science is—and is not—likely to be of service in resolving doubts about the nature and magnitude of environmental risks. □

Deregulation, Industrialization, and Arms Control

Deregulation Revolution

The Politics of Deregulation
by Martha Derthick and Paul J. Quirk
The Brookings Institution, $28.95

Reviewed by Richard Vietor

"We have worked hard," writes Ronald Reagan in his 1986 *Economic Report of the President,* "to identify and remove government regulations that impede the operation of markets." But as Martha Derthick and Paul Quirk point out in *The Politics of Deregulation,* a host of economists, regulators, and members of Congress worked even harder to deregulate various industries under the Carter administration. During that time airlines, trucking, and telecommunications—the three industries that are the focus of this book—as well as securities brokerage, railroads, banking, petroleum, and natural gas were largely freed of regulations designed to restrict competition. The changes in these important sectors have amounted to a virtual economic revolution.

The authors are pleasantly surprised but somewhat baffled by this outcome. Conventional wisdom says that agencies "captured" by the industries they are supposed to regulate, members of Congress motivated only by reelection, and the coordinated power of big business pose a formidable barrier to opening markets to more competition. Derthick and Quirk conclude that a "fusion of expert analysis with public opinion"—the politics of ideas—was the driving force behind efforts to deregulate, not economic and technological changes within industries.

The authors specifically pinpoint various economists' analyses of the effects of regulation as the source of reform. These analyses, done largely during the 1960s and 1970s, included *The Economics of Regulation* by the liberal economist Alfred Kahn. (Kahn later took an active role in deregulating the airline industry as head of the Civil Aeronautics Board [CAB] in 1977-8.) The cumulative weight of this research threw a glaring spotlight on the inefficiencies, inequities, and underlying irrationality of restraints on competition.

The economists did not allow their work to gather cobwebs. Instead, they evangelized against regulation, testifying before congressional committees, writing legislation, and helping shape the political strategies of ambitious members of Congress and regulatory commissioners. Gradually, their ideas became institutionalized within the process of congressional oversight, the rule making of regulatory agencies, and the administrative agendas of Ford, Carter, and finally Reagan.

Efforts to restructure the airline industry exemplify what became a familiar sequence. Law professor Stephen Breyer orchestrated the 1975 hearings on airline regulation held by Sen. Edward Kennedy (D-Mass.). As head of the CAB, Kahn opened up some airline markets to more competition and allowed companies some flexibility in what they could charge. And the Carter administration successfully pushed for the 1978 Airline Deregulation Act. Although most airlines, as well as all the affected unions, initially opposed deregulation, they failed to coordinate their opposition, and in the end their efforts collapsed altogether.

The outcome of the deregulatory push in trucking was similar. This effort starred Ralph Nader, Rep. Howard Cannon (D-Nev.), and Darius Gaskins, head of the Interstate Commerce Commission (ICC). It also included a host of clever ICC staff members—some newcomers, some converts to the deregulation cause, and others deferring to the inevitable. In this case, industry opposition was remarkably unified. The American Trucking Association managed to combine the diverse views of its membership, and the Teamsters Union also presented a united front in opposing deregulation. But neither group had much impact. Congress still passed the Motor Carrier Act of 1980, which substantially freed the trucking industry from price, product, and geographic constraints. Since then, prices have fallen dramatically, hundreds of entrepreneurs have entered the market, and existing firms have been restructured through mergers and diversification. The one drawback is that, as is now happening in the airline industry, wages have been depressed.

The story is more complicated in the telecommunications industry, and here the authors' decision to ignore economic and technological influences becomes less convincing. Deregulation of telecommunications has been implemented piecemeal over nearly 25 years and is still far from complete. Expert opinion concerning the feasibility and wisdom of such efforts has been divided, the Federal Communications Commission has proceeded hesitantly, and Congress has failed to pass any legislation, remaining ambivalent to this day. Opposition from the Bell System was intense—until January 1982. At that point, Charles Brown, AT&T's new chairman, embraced competition more ardently than either Congress or his competitors, who were not set up to compete head on with the industry giant.

The rationale for regulating this industry—the fact that the technology creates a natural monopoly, and that the public good is best served by maintaining such a monopoly—was different from that used to justify controls on airlines and trucking. In those industries regulation was instituted in response to "excess competition" during the Great Depression—an excuse, as Stephen Breyer and Alfred Kahn have both observed, that was never very compelling. Moreover, the extraordinary technological changes that have swept the telecommunications industry—including transistors and electronic switching, digital signals, and microwave, satellite, and fiber-optic transmission—have drastically altered the market. These technologies make it less difficult for new companies to enter the industry because many more products and services can be offered at lower capital costs. It's no wonder that regulations designed in the 1930s and 1940s could not withstand entrepreneurial and political pressures for change in the 1970s and 1980s. In this case, then, the authors' decision to ignore the effects of technological and economic change limits their argument.

ILLUSTRATIONS: EUGENE YELCHIN

Jennings was concerned with the changes that industrialization wrought in humanity's view of the universe.

Still, Derthick and Quirk have debunked several prominent theories of regulation while telling an interesting and insightful political story. If regulators in these industries were ever "captured," they certainly adjusted quickly to the drive for regulatory reform. The same can be said for congressional committees—the third prong in the so-called "iron triangle" opposing change. Theories that explain regulation as bureaucratic avoidance of turmoil, and that attribute political power to the collective action of vested interests, fare badly in these cases. The process of reforming economic policy, the authors conclude, can work under the right circumstances. That is certainly good news.

RICHARD VIETOR is a professor at Harvard Business School. His most recent book is Telecommunications in Transition *(Harvard Business School Press, 1986).*

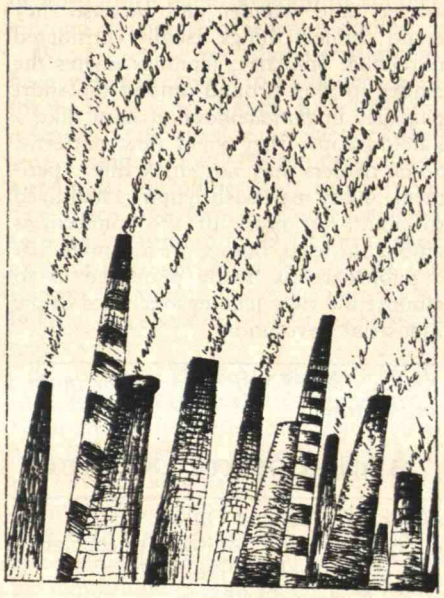
Industrialization Revisited

Pandaemonium
by Humphrey Jennings
The Free Press, $19.95

Reviewed by Karen Rosenberg

Many books enter the world with extravagant claims, but *Pandaemonium* is the rarity that almost apologizes for its existence. When filmmaker, poet, painter, and scholar Humphrey Jennings died in 1950, he left unfinished this massive anthology of reactions to the Industrial Revolution. A number of his friends and colleagues, including Charles Madge, the editor of this volume, attempted to interest publishers in completing the project. In the introduction to her father's work, Mary-Lou Jennings lists the presses who rejected the proposal—modesty that is refreshing in this age of hype.

What makes *Pandaemonium* unusual—and perhaps risky from a publisher's perspective—is that it isn't a social history but the primary material from which one could be constructed. Jennings searched out revealing passages written by witnesses to the beginnings of the industrial age, including excerpts from diaries, letters, memoirs, biographies, and scientific treatises. He was after sharp observations and poignant remarks, such as what engineer James Nasmyth wrote in his autobiography in 1830: "As I watched the



decaying trees I thought of the price we had to pay for our vaunted supremacy in the manufacture of iron."

Of course, Jennings found few writings by the uneducated, but he located travelers and political leaders who recorded workers' words—angry, hopeful, and resigned. Also scattered amid this wealth of reportage and philosophical speculation are poetry and prose fiction about the new world of machines and cities, including Charles Dickens' chilling description in *Bleak House* of bits of London soot "as big as full-grown snowflakes."

Jennings brought an eye for significant detail to his historical research from his experience in the arts. Like his friend the mathematician and cultural historian Jacob Bronowski, he pursued his varied interests passionately and brilliantly. Some eras beat students into specialties with the bugaboo of "dilettantism." Jennings was fortunate to have lived in a time and place that did not perceive an irreconcilable conflict among artistic, humanistic, and scientific proclivities.

His mind, not constricted to fit a preestablished career pattern, invented imaginative enterprises. In 1937, he and Madge founded an organization called Mass Observation to conduct anthropological research on the customs of the British Isles. *Pandaemonium,* which Jennings began around 1937, might be called his attempt at a mass observation of the British past. The British surrealist artist Roland Penrose remembered more than one encounter with Jennings when he was "immaculately dressed but carrying a heavy dilapidated suitcase." When Penrose asked what it contained, Jennings would answer, laconically, "Pandaemonium." The pun was undoubtedly intended.

Jennings was concerned with the changes that industrialization wrought in humanity's view of the universe, including the increasing tendency to see living creatures as machines. Robert Hooke, a seventeenth-century scientist, and other observers applied this metaphor to insects, but by the early nineteenth century a medical doctor concerned with sanitary reform referred to women and children employed in Manchester cotton mills as "the animal machine." Jennings also reveals people's complementary tendency "to invest the machine with some faculty of intellect," as Dorothy Wordsworth, sister of William, wrote in 1803.

In this context, poet William Blake appears less of a mystic and more of a prescient social critic. Jennings quotes not only his famous lines about "these dark Satanic Mills" but also the passage in "Jerusalem" contrasting the hourglass, the plough, and the waterwheel—condemned because of their simple workmanship—to the intricate wheels of factory machines invented so that youth "may grind/ And polish brass & iron hour after hour, laborious task,/ Kept ignorant of its use." The cult of the child and the countryside in William Wordsworth and Percy Bysshe Shelley becomes a danger signal pointing to industries that use child labor and pollute the land and air. Through these quotations Jennings suggests that the coming of the machine destroyed natural beauty and village life, and he reminds us that people's nostalgia for such values is a sign of loss.

"Pandaemonium" is John Milton's name for the capital of hell in *Paradise Lost* published in 1667, and Jennings includes the passage in which Milton describes how the fallen angels extract, smelt, and forge metals. Other passages that Jennings quotes show that mining conditions continued to shock visitors in the ensuing centuries. Their horror—even when expressed in antiquated English—cannot fail to touch us today.

Like the French and British surrealists with whom he collaborated, Jennings was concerned not just with what people think but also with what they feel—their fears and desires. The surrealists' bizarre juxtapositions fascinated him, probably be-

cause they could evoke emotions such as anxiety and wonder and because they could connect things usually considered unrelated. Similarly, Jennings invites the reader to skip around among the short passages in *Pandaemonium* until, like a kaleidoscope, they yield new patterns. Some readers may not enjoy this experiment; many may wish Jennings had lived to point out more of the connections among the texts. But we are fortunate that a publisher has finally permitted us to glimpse the view Jennings recorded of the Industrial Revolution.

KAREN ROSENBERG writes on politics and culture.

Arms-Control Doctrine

Hawks, Doves, and Owls
ed. by Graham T. Allison, Albert Carnesale, and Joseph S. Nye
W.W. Norton, $14.95

Reviewed by Lincoln Bloomfield

Much of contemporary arms-control doctrine was thought up, argued, shaped, and absorbed into official circles during the 1950s and 1960s. This was a time when a genuinely new paradigm was developed for the forthcoming age of nuclear parity, supplanting the idea that the United States could maintain nuclear superiority. The new doctrine held that America could deter the Soviets from starting a nuclear war by making U.S. strategic forces invulnerable to a first strike, thereby ensuring that this country could retaliate regardless of what the other side did first.

This doctrine, commonly known as "mutual assured destruction," has recently fallen on hard times. A revolution in miniaturizing and computerizing weapons and making them more accurate, Soviet exploitation that soured détente, and the Reagan administration's suspicion of arms-control agreements have put some of the old thinking in doubt. Both superpowers are also finding the competition in strategic arms ever more costly. Thus, diplomatic activity between the superpowers has again picked up, at least intermittently. Badly needed is a fresh analysis of the nuclear problem and a prescription for avoiding disaster.

In *Hawks, Doves, and Owls: An Agenda for Avoiding Nuclear War,* edited by Graham Allison, Albert Carnesale, and Joseph Nye, all of Harvard, various authors examine the ways a nuclear war between the superpowers could occur and offer strategies for preventing such an outcome. Many of these strategies are becoming the new conventional wisdom among arms controllers warily reemerging from their foxholes. The proposals include backing away from multiple-warhead missiles, which upset the strategic balance by concentrating retaliatory power in a small number of weapons, thereby tempting one party to strike first in a crisis. The ideas also include eschewing plans to "decapitate" the other side's command and control facilities, since such a strategy would make terminating a nuclear exchange that much harder. Working to resolve and prevent local conflicts that could trigger a superpower conflict is a third important ingredient of the new doctrine.

The book's editors set forth much of this prescription in several sound chapters, and several of the other authors also offer valuable insights. Paul Bracken discusses the threat to strategic stability posed by decision-making systems of unmanageable complexity. He worries that a false alarm could produce a nuclear war in a system that depends on computers to communicate. Henry Rowan fears that the strategic balance is becoming more precarious as more countries join the nuclear club. However, he also advances the unorthodox argument that the situation might actually become more stable as the number of nuclear powers increases, since Washington and Moscow might be less likely to react spastically to an unidentified nuclear explosion.

Yet none of these analysts deals with the concrete policy choices that the United States must make if it is serious about preventing dangerous local conflicts. For example, Francis Fukayama, an analyst with the Rand Corp., correctly maintains that the Mideast is the most likely place for the nuclear fuse to light. Yet he stresses the need to deter a Soviet invasion in that region—in my opinion the least likely event on which U.S. policy needs to focus.

Any serious effort to reduce the threat that Mideast conflicts will lead to nuclear war must deal with the need to establish a Palestinian homeland. Fukayama argues that such a homeland would be dangerous to Israel (and therefore U.S. security) because it could lead to a communist state on Israel's border. However, President Carter's successful effort to take Egypt, which accounted for more than half the Arab military power, out of the Mideast conflict significantly reduced the chances of another major war. An effort to take the Palestinians out of the conflict would undoubtedly have a similar effect. Camp David, for all its flaws, was worth more in terms of preventing nuclear war than endless strategic calculations about improbable contingencies with the Soviets.

In figuring out how to avoid such explosive local conflicts, the authors might have questioned the U.S. commitment to go to war to protect Mideast oil fields. These fields are now jeopardized by the six-year-old Iran-Iraq War. A 50-cent-a-gallon tax on gasoline at the pump or a 5-dollar-a-barrel surcharge on imported oil, plus a large-scale effort among the major oil-importing countries to develop alternative fuels and technologies, could eventually make Mideast oil irrelevant. Such a commitment would do more to prevent a superpower collision than the growing U.S. embroilment in a region of spectacular American (and, mercifully, Soviet) unpopularity.

The diagnosis the authors of *Hawks, Doves, and Owls* set forth is sound. However, there still remains a market for detailed prescriptions on how to better design, deploy, and control nuclear weapons to enhance world security, as well as on how to deal with crises arising from local conflicts that the superpowers usually do not control.

LINCOLN P. BLOOMFIELD, professor of political science at M.I.T., has served in the State Department and with the National Security Council.

COWEN

CONTINUED FROM PAGE 19

States has just stumbled from one limited manned space flight program to another with no clear sense of where it's going.

Why? Because no administration has been willing to commit to a long-term plan for the U.S. space program. Back in 1958, a report by the president's Science Advisory Committee did recommend long-term goals, including Mars exploration. The Space Task Group again considered such goals in the early 1970s but backed away from them. Now NASA and the Reagan administration have decided to build a space station, but its purpose remains vague.

In contrast, Moscow's program seems to follow a long-range strategy that the Soviets have often articulated. The present *MIR* (Peace) satellite is the first version of the Soviets' long-expected permanently manned space station. The station is to have both commercial and military uses, and it should also serve as a staging point for expeditions to the moon and Mars. The Soviet leaders' stated goal is to make the USSR a space-faring nation that can exploit space resources from asteroids, the moon, and Mars.

In time, the Rogers commission and NASA investigators will undoubtedly pin down the cause of the *Challenger* explosion. Deficiencies in managing launch safety can be remedied, although some painful reshuffling within NASA may be required to accomplish the job. But there is no easy fix for NASA's underlying troubles. The United States must rethink its space policy and establish long-term goals that it can realistically meet. A presidential commission report that was due to be released by now may help. It urges the United States to develop space resources by mining the moon and asteroids. It also encourages the exploration of Mars in the next century. I can only hope that Americans—and their elected representatives—will decide that such objectives are worthy of long-term national support. □

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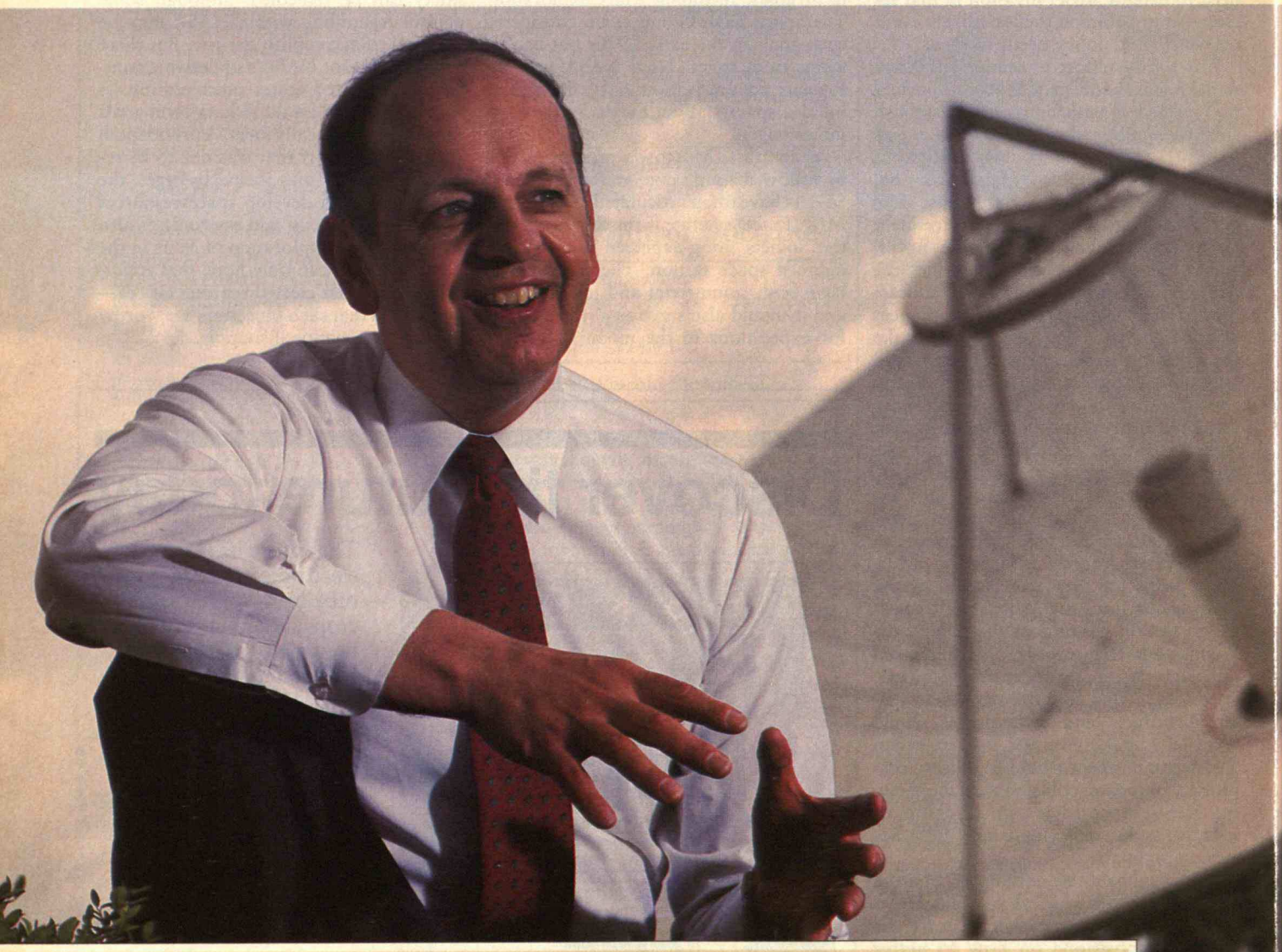

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dustrial countries spend less than we do on defense but much more in toto.

Americans are not overtaxed, they are undertaxed. The simple housekeeping functions of a modern industrial economy mean that it is not possible to run a government sector as small as that desired by President Reagan. Put bluntly, no one can balance the budget without a tax increase.

President Reagan has proposed a fiscal-1987 budget that seems to meet the first year's cuts mandated under Gramm-Rudman—without a tax increase. But he could do that only with phoney bookkeeping. He understated defense spending by $15 billion and overstated revenues by $15 billion. The Congressional Budget Office quickly corrected this budget, showing that even Reagan could not find the extra $30 billion in cuts that would have been necessary to meet the requirements of Gramm-Rudman honestly.

While no one can balance the budget without a tax increase, it is equally true that the American political system cannot raise taxes without the active support of the president. Only he can stand up and say that the country needs a tax increase. And if he chooses to say the opposite, no coalition of forces can pass an increase, and certainly not over his veto.

Political pundits argue as to whether President Reagan really means it when he says will tolerate no tax increase during his term in office. But I believe he means exactly what he says. There will be no tax increase. Since it is equally clear that Gramm-Rudman is not going to be implemented—Congress can overrule the law with a three-fifths majority—we are simply going to continue to live with large budget deficits for the next two and a half years.

While serious, this is not fatal as long as the rest of the world stands ready to lend us $150 billion a year as they are now doing. Foreigners essentially postpone the effects of our large budget deficits through their willingness to finance them. Since these loans eventually have to be repaid, this creates future problems. But it eliminates most of the adverse side effects of today's huge deficits.

The Inevitable Tax Increase

I would be willing to bet, however, that the next president, whether a Republican or a Democrat, will propose a very large tax increase on the first day of office. He or she will do so because a tax increase on day number one can easily be blamed on the mistakes of the preceding president. If the newest inhabitant of the White House waits until later, he or she will have to take the blame. The next president will know that it is highly unlikely that foreigners are going to be willing to finance U.S. budget deficits for another eight years even if they have financed them for the previous eight years. Eventually all lenders reach the point where they think the borrower has borrowed too much.

If you doubt this prediction, look at what almost all state governors do when they inherit large budget deficits from their predecessors. Whether we're talking about Democrat Madeleine Kunin of Vermont or Republican Richard Thornburgh of Pennsylvania (during his second term), the first thing each does on taking office is raise taxes. □

CONTINUED FROM PAGE 25

Scientists who stay in academia are increasingly excluded from research frontiers because of the lack of support for projects and new equipment. Given such conditions, it is hard to blame young scientists for choosing careers in industrial laboratories that are equipped with the latest instruments and that do not expect employees to spend time raising funds.

Doubling Our Support for Science

What is happening in condensed-matter physics today can be expected to happen throughout physics and the other physical sciences tomorrow. A recent chemistry survey by the NRC came to essentially the same conclusion: to assure continued excellence in science, federal funding for university-based research must roughly double over the next four or five years. A report released in January by the White House Science Council, chaired by David Packard (of Hewlett-Packard), also called for a substantial increase in funding for university research.

The federal government last year spent about $50 billion a year on R&D, and industry spent about the same amount. Thus, the total national R&D effort was about $100 billion. But nearly all these funds went for *development*. Only 2.5 percent of the R&D budget is spent on basic research in the physical sciences, and this includes research carried out in federal and industrial laboratories as well as at universities.

The total budget for university-based physics was about $400 million—less than one-half of one percent of the national R&D budget. Considering that many of our national R&D programs would not even exist today if the nation had not adequately supported university-based research in the past, that fraction is too small. Unless we invest more in university-based science, the United States will lose its capability for training first-rate scientists, and its universities will no longer be world-class centers of science.

If this warning sounds alarmist, bear in mind how rapidly things change. Two decades ago the United States undoubtedly possessed a unique genius for translating new technology into commercial products. Today the best place to see Yankee ingenuity in action is in Japan. Is there any reason to doubt that we could lose scientific leadership just as quickly? □

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Safer Mining, Cheaper Oil

Automated Mining

Despite years of research and volumes of regulations, underground coal mining is the most dangerous occupation in the United States. The rate of disabling injury per ton of coal mined remains stubbornly high, even growing.

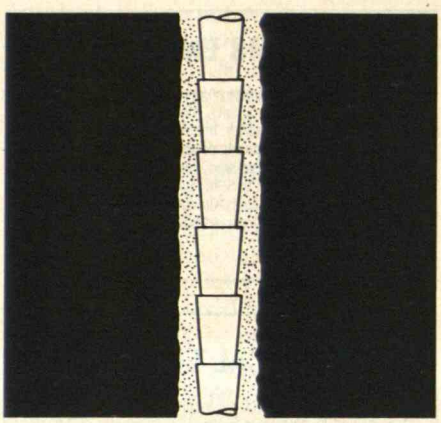
Safer mining will require a wholly new strategy, says Carl R. Peterson, associate professor of mechanical engineering at M.I.T. Since we've failed to remove the hazard from the miners, we must remove miners from the hazard.

In other words, says Peterson, remote control of all mining operations.

In a new Center for Innovative Mining Systems, Peterson and several colleagues from Pennsylvania State University will study the use of advanced computer technologies—even artificial intelligence—to automate coal mining. It's an ambitious concept, says Peterson, because most underground coal-mining systems will have to be redesigned so they are simpler and more amenable to automation.

The first fruits of the new center are now close to completion. One is an automatic control system that can keep a tunneling machine on course by observing changes in the direction of rock and coal layers through which the machine is cutting. There's also a new set-in-cement wedge that can be installed automatically by a mining machine to secure the rock above.

These two devices share an important attribute: both can be used in today's mines as well as tomorrow's. That's necessary because the industry lacks resources to completely replace today's mining systems with comprehensive new ones, says Peterson. So progress toward the redesigned mining systems that are the goal of the Center for Innovative Mining Systems will have to be sequential—one step at a time—Peterson told the American Society of Mechanical Engineers late last fall.



This new steel anchor for mine-tunnel roofs is one of the first developments from a Center for Innovative Mining Systems at M.I.T. and Pennsylvania State University. The anchor is inserted in a hole drilled in the mine roof, and then the hole is filled with cement. If the roof starts to sag, the wedge acts to increase the friction between concrete and rock, thus preventing collapse. Tests have shown strengths double those of conventional bolts, says Professor Carl R. Peterson.

Adelman's Hazy Crystal Ball

The lesson of today's low oil prices is that the marketplace, not the prospect of ultimate resource exhaustion, dictates price. In this sense, oil is just like aluminum, tin, cobalt, and a score of other minerals for which the United States depends on overseas suppliers.

What happened in the 1970s when crude oil prices were twice ratcheted up? It was not that the world suddenly recognized its great dependence on gradually depleting oil resources. It was simply that OPEC succeeded in doing what it cannot do now—controlling production, says Morris L. Adelman, professor of economics whose studies of the world oil market have often put him in a spotlight.

Though recent events have strained the cartel, OPEC is by no means defunct, says Adelman. Granted, the odds that it will regain enough control to generate another upward ratchet of prices are slim. But they're not "infinitesimal," and the Strategic Petroluem Reserve that now contains nearly 500 million barrels of oil is a vital buffer for the United States.

Will prices continue to slip? Probably, thinks Adelman, because OPEC lacks the strength to enforce production constraints. Indeed, if peace comes to Iran and Iraq and their wells go back into production, he says, "hang onto your hat!"

What will happen by 1995, 10 years from now? Not much will change, says Adelman: "permanent instability." Oversupply is almost certain, and "severe downward pressure on prices will last as long as we can foresee." All he can be sure of are the limits: the price will not fall below the cost to produce the oil that the world needs, nor will it rise above the cost of producing substitutes such as synfuel from coal. That's a wide range, hardly a prediction at all. The price of substitutes is high—$60 to $70 a barrel. And the cost to produce crude is low—about $8 a barrel in the U.S., $2 a barrel in parts of the Middle East, where new reserves producible at low cost continue to be found.

Social Engineering

Though much of societal change is the result of new technology, engineers shy away from questions about how society will use their new achievements.

Two reasons for this anachronism, said President Emeritus Jerome B. Wiesner of M.I.T. in his address early this year upon receiving the National Academy of Engineering's Arthur M. Bueche Award:

☐ Engineers have little or no training or experience with policy problems.

☐ Too often engineers sense a conflict of interest because the groups they work for have a stake in the profitable exploitation of their technology.

Wiesner's response is to urge engineers and social scientists to come closer together. "The societal consequences of technology should be as much a part of the engineer's intuitive mental power as calculus or computer programming," he said. And the political process needs to be enriched by engineers' ways of thinking: changes are really experiments, and at first their scale should be minimized so that the inevitable errors aren't too costly.

No Hazard in Tax Reform

Today's office building boom will continue even if tax laws on real estate investment are changed drastically, says Professor William C. Wheaton in a report for M.I.T.'s Center for Real Estate Development.

Wheaton explains that the rapid depreciation provided in the 1981 tax law, proposed to be eliminated in future tax reform, has meant little in today's building boom. Financial deregulation—especially permitting pension funds to make real estate investments—is a bigger factor.

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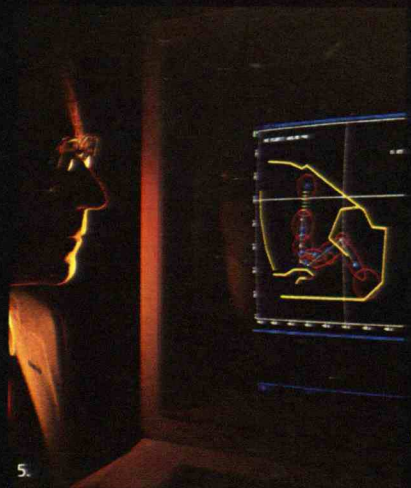

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